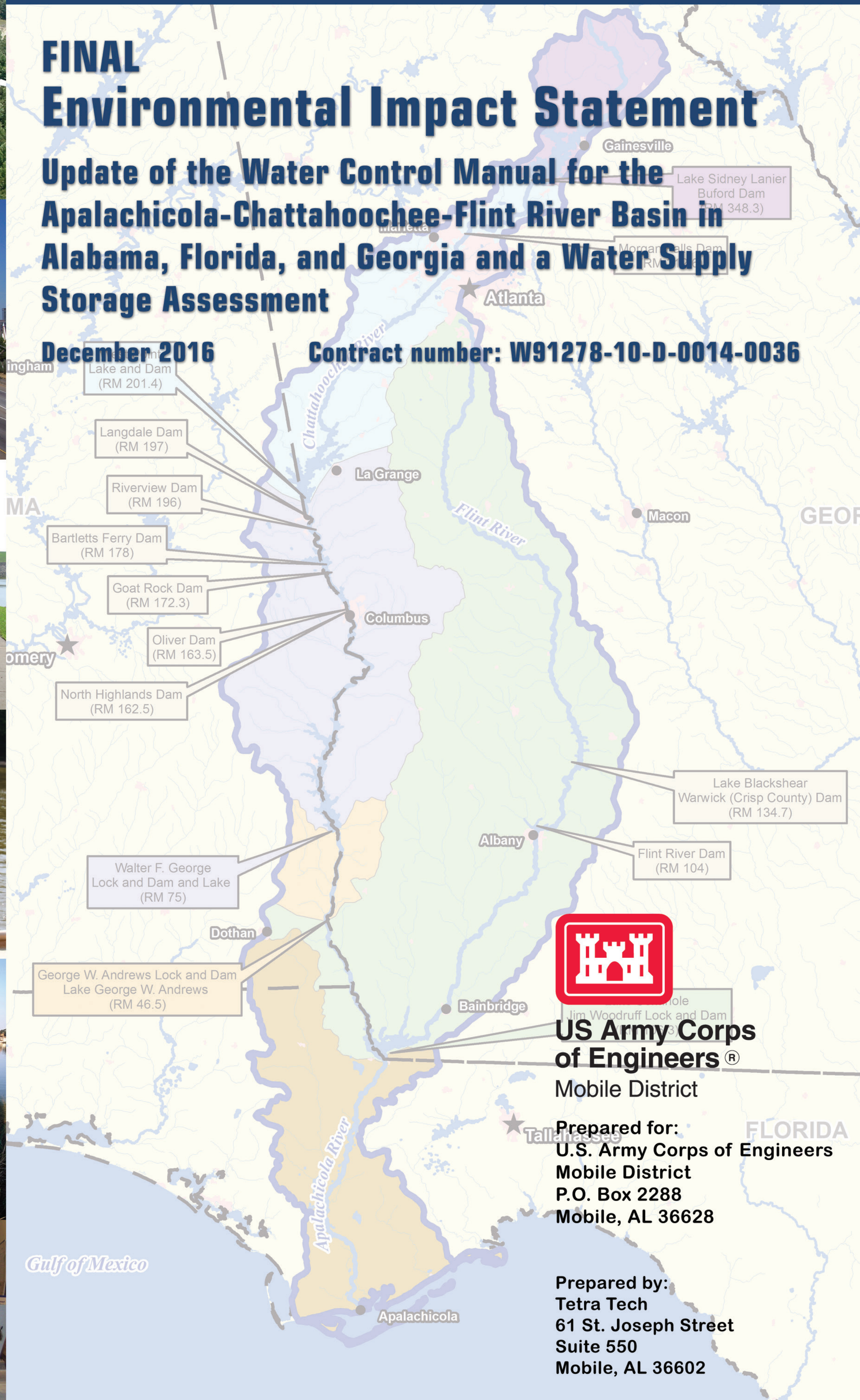
Volume 5: Appendices D—I

FINAL
Environmental Impact Statement

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

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



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Appendix D

Summary of Public Scoping Input

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Scoping Comments and USACE Analysis of Scoping Comments

The public scoping effort (2008, 2009, and 2012) for updates to the Master WCM resulted in a total of 3,600 comments from over 960 individuals, organizations, and agencies. All the comments from scoping were reviewed, analyzed, and organized into categories based on the nature of the comments.

The greatest number of comments (1,228) was related to water management recommendations, which include the seven authorized project purposes and USACE ability to balance needs throughout the ACF Basin. Other comments in that category addressed potential alternatives for consideration (or potential mitigation measures); demand projections as they relate to downstream and future water supply needs; and water conservation. Issues and concerns regarding socioeconomics and the tie between water levels, recreation, and regional economics received the second-largest number of comments (706). Most of the comments received in this category pertained to the adverse socioeconomic impacts that have occurred in the northern portions of the ACF Basin due to extremely low water levels in Lake Lanier and low or inconsistent water levels in West Point Lake during periods of drought and drought recovery.

The scoping comments expressed by the three states are consistent with their respective positions over the litigation history as summarized in the EIS as well as their subsequent comments on the draft EIS. Although there is a more in-depth analysis in the EIS, a few key issues identified by the states and stakeholders in the states are summarized in the following sentences. The state of Florida disagreed with the process and models used by the USACE; aside from these procedural and technical matters, Florida also sought additional flows into the Apalachicola River and Apalachicola Bay. The state of Alabama also took issue with the process and models. In addition to the stated procedural and technical concerns, Alabama also wanted assurances that specific minimum flows would be met or exceeded at all times for industrial interests in Alabama. Both Florida and Alabama wanted to limit Metro Atlanta's withdrawals from Lake Lanier and the Chattahoochee River, including requirements for greater water conservation measures and limits on consumptive use. The state of Georgia wanted water supply contracts at Lake Lanier and increased water supply withdrawals from the Chattahoochee River downstream of Buford Dam, both to meet projected future water demands for Metro Atlanta, as well as more conservative use of storage in the ACF Basin reservoirs, which would benefit pool levels for recreation and water supply at Lake Lanier and West Point Lake.

Stakeholder comments were helpful in identifying water resources/water management problems as well as measures (or alternatives) the public wished to have considered as the Master WCM is updated. Considering the purpose and need for this EIS, USACE developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. The screening criteria helped to define the scope of proposed updates to the Master WCM, identify relevant public/agency issues and concerns to be addressed in the EIS, and guide the consideration of input received from agencies and the public, as well as suggestions from USACE project team. Any proposed measure (or alternative) considered in the update process for the Master WCM should:

- Meet the purpose and need of the proposed federal action
- Address one or more of the congressionally authorized project purposes
- Maintain at least the current level of flood risk management
- Be consistent with the contemporary water resources needs of the basin to the extent practicable
- Support the operation of the projects in the ACF Basin as a system
- Not increase the risk to public safety in the facility or downstream of the project
- Not exceed the physical limitations or pose risks to the structural integrity of the projects
- Not violate USACE responsibilities under the ESA

The USACE has not developed formal responses to the comments received during scoping but reviewed the comments and suggestions received as categorized in the Scoping Report and developed summaries of the major themes. The major comments and suggestions received during the scoping process are shown in the table below together with a statement of whether or how the comment or suggestion was eliminated by the screening criteria or whether the comment was considered in updating the WCM. The table defines the major comment categories using a comment identifier (ID) and includes the section in the environmental impact statement where the comment was addressed.

Number	Scoping Comment	USACE Response/Action	EIS Reference
Water Management (WM)			
WMI	More and better lake and stream gages are needed.	The USACE continually strives to improve water management technology or to utilize the best available information.	Section 4.1.1; Appendix A
WM2	The USACE should comply with the federal laws establishing the primary purposes of these [ACF] projects.	The USACE will comply with all applicable federal laws, regulations, and congressional authorized purposes for the ACF Basin federal projects.	Section 3.2; Section 3.6; Section 6; Tab 6-1
WM3	The ACF Basin flows need to mimic components of natural flow variability.	The USACE will consider alternatives to current operations. However, the purpose and need of the proposed federal action is to update the WCM to determine how the federal projects in the ACF Basin should be operated for their congressionally authorized purposes, in light of current conditions and applicable law, rather than to restore the ACF Basin to pre-project conditions. Any reasonable alternative must satisfy that purpose and need.	Section 4.1; Appendix J
WM4	The USACE should incorporate variable flows in the new WCM, including the seasonal, intra-annual, and inter-annual flow patterns needed to maintain or restore processes that sustain natural riverine characteristics.	Same as WM3	Section 4.1.2; Appendix J
WM5	The WCM update should address how it will impact future water, wastewater, or watershed management plans of the Metropolitan North Georgia Water Planning District (MNGWPD) that would restrict or place additional unfunded mandates on the district’s operations?	The water supply needs of the region have been described in a request made by the State of Georgia on January 11, 2013. A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier	Section 5.1; Appendix B
WM6	West Point Lake levels do not meet authorized purposes.	Updating of water control plans and manuals will ensure that operations comply with all congressionally authorized purposes for the ACF Basin projects.	Section 2.1.1.1.6.3; Section 4.1
WM7	The USACE must consider alternative operating plans to balance upstream needs with downstream needs before adopting a new water control plan	The USACE will consider a range of measures when updating water control plans and manuals to achieve congressionally authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin.	Section 4.1
WM8	Water should not be released from Lake Lanier unnecessarily. It is wasteful.	Same as WM7	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM9	The USACE should operate the ACF Basin in a run-of-river operation, like the public electric power companies do for their reservoirs. Run-of-river is the correct baseline to be evaluated in the EIS.	Same as WM3	Section 4.1.1
WM10	The USACE has to stop operations that favor elevated lake levels at the expense of river flow. The USACE has effectively shelved about 25 percent of Lake Lanier's total conservation storage, removing it from the USACE's daily operating protocol, with future drought as the justification.	Lake Sidney Lanier was designed as a multipurpose storage reservoir and is operated as such. The USACE will consider a range of measures when updating water control plans and manuals to achieve congressionally authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin.	Section 4.1
WM11	Lake Lanier is not properly managed.	Same as WM7	Section 4.1
WM12	In developing its alternatives, the USACE should de-emphasize use of any discretionary operational policy in favor of operating to maximize water supply, an authorized purpose of the project.	Pursuant to the U.S. Court of Appeals for the Eleventh Circuit decision of June 28, 2011, and USACE's 2012 Legal Opinion, the updated manuals will reflect that USACE has (1) the legal authority under the River and Harbor Act (RHA)of 1946 to release water from Buford Dam sufficient to accommodate Georgia's requested downstream withdrawals of 408 mgd and (2) the discretion under the Water Supply Act of 1958 to accommodate withdrawals from Lake Sidney Lanier (withdrawals of 20 mgd are already authorized under relocation agreements). The USACE will consider a range of measures when updating the WCM to achieve the authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin.	Section 5.1; Appendix B
WM13	USACE's operations should encourage and facilitate return flows to Lake Lanier, including providing direct 1:1 credit to entities providing return flows to the lake.	The USACE will consider current and projected return rates, including water supply storage alternatives reflecting varying amounts of withdrawals and returns. Any water supply storage contracts that the USACE may enter into would address return flow accounting.	Section 5.1; Appendix B
WM14	The WCM update should evaluate operational alternatives that mitigate the extreme nature of Buford Dam short-term (daily/hourly) flow fluctuations while at the same time ensuring ample minimum flows to maintain water quality, waste assimilation, and improve conditions for aquatic flora and fauna.	Same as WM10	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM15	The EIS should evaluate operational measures that could be adopted to ensure that increasing incidence of regional drought and/or growing demand for water within the Chattahoochee Basin does not result in unexpected or unavoidable dips in flow within Chattahoochee River National Recreation Area (CRNRA).	The USACE will generally evaluate the flows that could result from different operational measures and alternatives. However, the authorized purposes of the ACF system do not include specific flow requirements within the CRNRA.	Section 4.1
WM16	The EIS must include a complete assessment of the impacts of revised operations on the Middle Chattahoochee region.	Key flow requirements for municipal and industrial (M&I) users in the middle reach of the Chattahoochee River will be considered in modeling for the updated WCM and EIS. The USACE will generally evaluate the flows that could result from different operational measures and alternatives. The authorized purposes of the ACF system do not include specific M&I flow requirements for the middle Chattahoochee River.	Section 6.1.1.2
WM17	The governors of Alabama, Florida, and Georgia in 2003 signed an agreement establishing flow parameters for the ACF river system. In revising the ACF WCM, the USACE should plan to operate the system in accordance with those agreed upon flow parameters: the middle and lower Chattahoochee flow requirements of 1,350 cfs daily average and 1,850 cfs weekly average at Columbus, Georgia, and 2,000 cfs daily average at Columbia, Alabama	Key flow requirements for municipal and industrial (M&I) users in the middle reach of the Chattahoochee River will be considered in modeling for the updated WCM and EIS. However, the authorized purposes of the ACF system do not include specific M&I flow requirements for the middle and lower Chattahoochee River, at Columbus, Georgia, or at Columbia, Alabama.	Section 6.1.1.2
WM18	FERC [Federal Energy Regulatory Commission]-approved flows [at Columbus, Georgia] of 800 cfs minimum, 1,350 cfs daily average and 1,850 cfs weekly average are critical and necessary to sustain the aforementioned projects and programs at Columbus and southward.	The USACE is aware of the Georgia Power Company (GPC) projects and their FERC minimum flow requirements. They will be recognized in the updated WCM and EIS. The USACE minimum flow requirement from West Point Dam is 675 cfs. The authorized purposes of the ACF system do not include operation of the West Point project to ensure that GPC complies with its FERC license	Section 6.1.1.2
WM19	The updated WCM should include assessment of the water use needs necessary to maintain generation of the GPC facilities as part of the baseline conditions in the ACF Basin and plan for future generation of electricity to meet growing population demand.	The USACE is not specifically authorized, or otherwise obligated, to operate ACF Basin projects to meet certain minimum flows at the GPC plants. All ACF Basin projects are operated for their congressionally authorized purposes.	Section 6.1.1.2

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM20	West Point Lake levels should never drop below 630 feet (ft).	Any considered water management alternative should maintain at least the current level of flood risk management. Additionally, this suggestion could pose risks to the structural integrity of the project, could pose risk to public safety of the facility or downstream of the project, and could affect the availability of flows to comply with the USACE's obligations under the ESA.	Section 4.1.1
WM21	Updating the plan should include new methods of forecasting runoff and modeling to ensure that the USACE's ACF reservoirs, particularly Lake Lanier, are allowed to reach full pool no later than June 15 of each year and are as full as practical during drought conditions while still meeting downstream, legally required flows.	The USACE is working with Southeast River Forecast Center to use Ensemble Streamflow Prediction (ESP) inflows to perform 3–6 month forecasting during drought conditions. Further, the USACE is working closely with National Integrated Drought Information System (NIDIS) (www.drought.gov) to develop a Southeast-ACF Drought Early Warning Information System. The pilot project is in response to the latest 2006–2009 drought. The goal of the project is designing a drought early warning information system in the ACF Basin. Both efforts will incorporate updated forecast methods performed by the River Forecast Center. The USACE will consider operations to ensure reservoirs achieve full pool by the beginning of the summer recreation season.	Appendix A; Section 2.1.1.3; Section 4.1
WM22	Lake Lanier is critical for the water supply of metropolitan Atlanta.	The USACE will address the impact of ACF system operations on water supply needs of metropolitan Atlanta, including consideration of Georgia's water supply request.	Section 5.1; Appendix B
WM23	The project purposes in the ACF Basin are outdated and need to be changed.	This suggestion does not meet the purpose and need for this EIS, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin. Only Congress has the authority to change the authorized purposes of the ACF system.	Section 1.3; Section 4.1.1
WM24	The ACF Basin manual update should have a summary of operational changes necessitated by drought operations requirements and the new data that support such changes.	Update of the WCM will include development of a drought operations plan.	Section 4.1
WM25	The ACF Basin manual update should have a section with updated data reflecting current basin conditions.	Update of the water control plans and manuals will include the most recent available data regarding basin conditions.	Section 2

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM26	The ACF Basin manual update should have a section with proposed new environmental requirements for meeting water quality standards, and a section on how compliance with all federally listed threatened and endangered species laws and fish spawning needs will be accomplished.	The EIS will address the effects of changes in water management on water quality, federally listed threatened and endangered species, and fish spawning needs. USACE is not authorized to establish or enforce water quality standards.	Section 6.1.1; Section 6.1.2
WM27	The ACF Basin manual update should have a section with the results of the most recent computerized modeling used to evaluate project operations.	This EIS will include basin-wide modeling to evaluate considered changes in water management at the ACF Basin projects.	Section 4.1; Section 6; Appendix E; Appendix K
WM28	The Mobile District should address and fully document the effects from any proposed action(s) (e.g., revisions to various lake levels, discharge changes in average daily flows, etc.) on any federally listed threatened and endangered species	The USACE will consult with USFWS under Section 7 of the ESA regarding threatened and endangered species.	Section 6.4.3; Appendix J
WM29	The USACE should include in the EIS a discussion that connects management plans to reallocation of water storage. Of special interest are the effects of management plan changes on discharge rates (including velocities) and river elevations (including volume).	Refer to WM12. The WCM update and EIS will address any revisions to water management procedures necessitated by a reallocation of storage to water supply.	Section 5.1
WM30	Water supply withdrawals (or the lack thereof) [from Lake Lanier] and their consequences should be examined as impacts of the proposed federal action	Refer to WM12.	Section 5.1; Section 6.5.1
WM31	Instead of merely documenting current operations, the USACE must develop and analyze alternatives that will make the most efficient use of the water resources in the ACF Basin.	In updating the WCM, the USACE will consider potential management changes that could result in more efficient use of water resources within the limits of congressionally authorized purposes and applicable law.	Section 4.1; Section 5.1; Section 6
WM32	The USACE should consider the formal reallocation of storage in the federal reservoirs to meet current water supply needs and projected future water supply needs	Refer to WM12	Section 5.1; Appendix B
WM33	The USACE should consider possible changes to the rule curve operations at all of the federal ACF reservoirs to maximize available storage and optimize operations for all project purposes.	Changes in guide curves and action zones at projects in the ACF Basin will be considered in updating the WCM. However, any alternative considered should maintain at least the current level of flood risk management.	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM34	The USACE must consider alternative action zones that reflect a more balanced pursuit of the project's multiple purposes. In addition, USACE must consider adjusting the action zones so that a significantly lesser percentage of the conservations storage pool is in Zone 4.	A principal goal of USACE WCMs is to balance competing water management objectives. Changes in guide curves and action zones at projects in the ACF Basin will be considered in updating the WCM.	Section 4.1
WM35	The USACE should balance the reservoirs, instead of following the May 2012 RIOP that allows the USACE to not balance reservoir operating zones during droughts and allows water to be stored in Lake Lanier at the expense of the downstream reservoirs.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of the ACF Basin. The USACE will consider a range of measures when updating water control plans and manuals to achieve congressionally authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin and complying with the requirements of the ESA.	Section 4.1
WM36	The USACE should adjust action zone elevations so that the effects of increased demands are borne primarily by the zone responsible for the increases in demand.	Changes in guide curves and action zones at projects in the ACF Basin will be considered in updating the WCM.	Section 4.1
WM37	The USACE should not limit possible alternatives to only those that mimic the manner of operations described in the RIOP. Instead, the USACE should consider alternatives to current operations such as the concept presented by the Atlanta Regional Commission and its consultant, Hydrologics, Inc., in January of 2007.	Same as WM35	Section 4.1
WM38	The updated manuals should provide for the equitable sharing of the additional storage obtained by the diversion of water to storage from December through February. In addition, the refill provisions should be more constrained with required releases during December – February at higher levels than 5,000 cfs.	Same as WM35	Section 4.1
WM39	The HEC-ResSim simulations may greatly underestimate the impact of the June 2012 "Improved" operations on reducing releases to Apalachicola River during "Emergency" Drought Operations. Worst case scenarios should be simulated which examine the potential impacts on releases to Apalachicola River if reservoir operators exercise the broad discretion allowed under the interim operating procedures in a manner different from the base model assumptions.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of Jim Woodruff Dam. HEC-ResSim modeling conducted for this EIS is intended to reflect day-to-day operations specified by various water management alternatives and not unique or unusual operation.	Section 4.1; Section 6.1.1; Appendix A

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM40	The USACE's operating plans should always maintain the ability to reduce flow below 5,000 cfs [below Jim Woodruff] during serious and prolonged droughts.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of Jim Woodruff Dam. On the basis of that consultation, a revised minimum flow might be established at Jim Woodruff Dam.	Section 4.1
WM41	The improved RIOP increased the occurrence and duration of extreme low flows to the Apalachicola River. The WCM update should correct this inequity and recognize that there are limits on the level of consumptive withdrawals in the Georgia portion of the ACF Basin.	Same as WM35	Section 4.1 Section 5.1 Section 6.4.3 Appendix J
WM42	The USACE needs to show the data that justifies the management measure of 5,000 cfs flow at the Florida line for the Apalachicola River. This flow rate is not needed, is unsustainable, and is detrimental to upstream lakes (West Point Lake and Lake Lanier). The Endangered Species Act does not require the USACE to augment the Apalachicola River flows above run-of-river levels.	Same as WM35	Section 4.1 Section 6.4.3 Appendix J
WM43	The USACE updated WCM should consider other operating rules besides the current RIOP based on keeping more water in the reservoirs and still meeting the minimum required flow including changing the action zones and guide curves in all the reservoirs.	Same as WM35	Section 4.1
WM44	The USACE should consider options for repairing and reversing channel degradation in the Apalachicola River.	This suggestion would not be within the scope of the proposed federal action, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 1.3; Section 4.1.1
WM45	The USACE should consider halting or limiting the current diversion of fresh water caused by the Chipola Cutoff.	This suggestion would not be within the scope of the proposed federal action, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 1.3; Section 4.1.1
WM46	The USACE should continue to use the HEC-5 model rather than the HEC-ResSim model.	The USACE considered continued use of HEC-5 rather than HEC-ResSim for river system modeling, but it concluded that HEC-ResSim is the most current accepted reservoir modeling tool and has superior capabilities for purposes of this action.	Section 4.1; Appendix E

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM47	The USACE should provide a summary of the current operating rules for each project, an explanation of their basis in congressionally authorized purposes, and a description of how much discretion the USACE has to change the rules.	The EIS will explain project purposes, existing water management processes, and the USACE's discretion in operating the projects.	Section 2.1.1.2; Section 5.2.1
WM48	The USACE should facilitate a comprehensive process for determining how ecological and social benefits could be increased by modifying the operations of the ACF federal dams. The approach described by Richter and Thomas (2007) would be very useful for this WCM update	This effort is not a comprehensive study to determine how ecological and social benefits could be increased in the region. However, the EIS will address the ecological and social effects of the proposed federal action and alternatives.	Section 6.1.2; Section 6.4; Section 6.5
WM49	The USACE should acknowledge the statutory authorized purposes for the ACF reservoirs and operate projects in the ACF Basin for their congressionally authorized purposes.	All ACF Basin projects will be operated for their congressionally authorized purposes and in compliance with all applicable federal law.	Section 1.3; Section 2.1.1.2; Section 3
WM50	The USACE cannot change authorized project purposes in the updated WCM without the consent of Congress.	All ACF Basin projects will be operated for their congressionally authorized purposes and in compliance with all applicable federal laws. The purpose and need of this EIS to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 1.2; Section 1.3; Section 3
WM51	To satisfy the USACE's obligations under federal law, including NEPA, the USACE must focus on the authorized purposes of Lake Lanier (hydroelectric power, navigation, and flood risk management).	Same as WM49	Section 1.3; Section 2.1.1.2; Section 3
WM52	Lake Lanier should be raised 2 ft [to conservation pool elevation 1,073 ft].	Any considered water management alternative should maintain at least the current level of flood risk management. Additionally, this suggestion could pose risks to the structural integrity of the project, could pose risk to public safety of the facility or downstream of the project, and could affect the availability of flows to comply with the USACE's obligations under the ESA.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM53	The West Point Lake action zones should be considerably narrowed or reduced to a range varying no more than 3 ft with a level never lower than 633 ft—except for dire emergency.	Changes to West Point Lake action zones will be considered as part of the update of the water control plans and manuals. Any considered water management alternative should maintain at least the current level of flood risk management. Additionally, this suggestion could pose risks to the structural integrity of the project, could pose risk to public safety of the facility or downstream of the project, and could affect the availability of flows to comply with the USACE's obligations under the ESA.	Section 4.1.1
WM54	The USACE should not implement its proposed management measure to start the West Point Lake winter pool draw down in September instead of November. The bottom of the conservation pool for the lake should be 632 msl.	Same as WM52	Section 4.1.1
WM55	The management objective for the interstate waters of the ACF Basin should be the identification, construction, and enforcement of a water budget that recognizes and balances the competing needs of all riparian users.	That alternative is outside the USACE's authority. States, not the USACE, are responsible for issuing water use permits. Therefore, that alternative does not meet the purpose and need, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 1.2; Section 1.3; Section 3; Section 4.1.1
WM56	The USACE should limit the Lake Lanier outflow to the inflow when the water level reaches a certain level.	Lake Lanier was designed as a multipurpose storage reservoir and is operated as such. Therefore matching outflow to inflow violates reservoir operating principles, is not technically feasible, and would not allow all project purposes to be met. In updating the WCM, the USACE will assess different operating schemes, and include assessment of drought operations	Section 4.1
WM57	If there is no other practicable way to protect the north end, split the lake by building another dam at or near Browns Bridge. Maintain the water level of the new Little Lake Lanier at a constant level of 1,071 ft, and any additional water that is available could be discharged into the main lake and managed there.	Construction of a new dam in Lake Lanier is outside the USACE's authority, would require additional congressional authorization, and will not be considered as part of the update of the WCM.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM58	West Point Lake should not be the *workhorse* of the ACF Basin.	The USACE's ACF Basin water control operations consider all project functions and account for the full range of hydrologic conditions from flood to drought. Because actions taken at the upstream portion of the basin affect conditions downstream, projects in the ACF Basin are operated as a system rather than as a series of individual, independent projects. The balancing of water control operations to meet each of those purposes varies between the individual projects and time of year. Operation of the projects is usually performed in a manner that represents a consideration of the often competing purposes and, whenever possible, the USACE manages the reservoir operations to accommodate the purposes in a complimentary fashion.	Section 4.1
WM59	As the USACE revises its ACF WCM, it is the position of Southern Nuclear that the USACE must ensure (1) minimum flows of 2,000 cfs in the Chattahoochee River at Columbia, Alabama; (2) support of navigation on the Apalachicola and Chattahoochee rivers; and (3) operation of the USACE's ACF reservoirs for their congressionally authorized purposes.	The authorized purposes of the ACF system do not include operating to meet certain specific minimum flows at Columbia, Alabama. In updating the WCM, the USACE will consider how to support navigation on the ACF system given the constraints in the Apalachicola River. All ACF Basin projects are operated for their authorized purposes.	Section 4.1.1 Section 4.1.2 ff
WM60	The USACE WCM must ensure that a flow of 2,000 cfs and elevation of 76 msl is maintained at Plant Farley (at Andrews Lock and Dam) so it meets its NPDES permit limits and requirements.	The authorized purposes of the ACF system do not include operating to meet certain specific minimum flows at Plant Farley.	Section 4.1.1
WM61	Maintain historical flows in the Apalachicola River and into Apalachicola Bay.	The USACE will consider a range of measures when updating water control plans and manuals to achieve congressionally authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin and complying with the requirements of the ESA. In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of Jim Woodruff Dam. On the basis of that consultation, the USACE might establish a revised minimum flow at Jim Woodruff Dam.	Section 4.1
WM62	Incorporate the use of water conservation measures into the WCM update.	Measures considered by various water users to reduce the consumption of water within the ACF Basin will be described in the EIS, to the extent information is available to the USACE. Requiring the implementation of such measures is generally a state and local responsibility, not a USACE responsibility. In updating the WCM, the USACE will incorporate a drought operations plan that emphasizes conservation of water in storage when drought conditions exist.	Section 4.1.1; Section 4.1.2

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM63	Keeping West Point Lake at full pool throughout the recreation seasons (March through November) is very important.	In updating the WCM, the USACE will consider guide curve changes at ACF Basin projects that might provide additional recreation benefit.	Section 4.1
WM64	The USACE should allow Lake Lanier to reach full pool no later than June 1 of each year.	The guide curve at Lake Lanier provides for reaching full summer pool elevation by May. In updating the WCM, USACE will consider guide curve changes at ACF Basin projects.	Section 4.1
WM65	The USACE needs to build a large lake on the Flint River to help control the water needed downstream.	Construction of new improvements on the Flint River is outside current USACE's authority and will not be considered as part of the update of the WCM, because it would not meet the purpose and need to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 4.1.1
WM66	Sikes Cut should be closed to lower salinity levels in Apalachicola Bay.	Sikes Cut is a segment of the Apalachicola Bay project, federally maintained channel. Such proposals do not meet the purpose and need to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 4.1.1
WM67	Action zones at the West Point project that are more harsh and severe than at any other lake in the ACF Basin must be eliminated or significantly reduced in their magnitude.	Changes to West Point action zones will be considered as part of the update of the WCM. The USACE's ACF Basin water control operations consider all project functions and account for the full range of hydrologic conditions from flood to drought. Because actions taken at the upstream portion of the basin affect conditions downstream, the USACE operates the projects in the ACF Basin as a system rather than as a series of individual, independent projects. The balancing of water control operations to meet each of these purposes varies between the individual projects and time of year. The USACE projects' operations are usually performed in a manner that represents a consideration of such often competing purposes and, whenever possible, the USACE manages reservoir operations to accommodate the purposes in a complimentary fashion.	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WM68	The West Point Lake Rule Curve needs to be adjusted upward to a minimum 632.5 msl and the Action Zones need to be modified upward as well to a minimum 630.0 msl at the bottom of Action Zone 4. The parameters of 632.5 and 630.0 msl are significant because they represent the initial and Sectionond recreation impact levels respectively as defined by the USACE.	Changes to West Point Lake action zones will be considered as part of the update of the WCM. Any considered water management alternative should maintain at least the current level of flood risk management. Additionally, this suggestion could pose risks to the structural integrity of the project, could pose risk to public safety of the facility or downstream of the project, and could affect the availability of flows to comply with the USACE's obligations under the ESA.	Section 4.1
WM69	The USACE should maintain Walter F. George Lake at a minimum of 187 msl.	USACE strives to operate the Walter F. George project to maintain a minimum pool elevation of 188 ft in the winter; however, basin hydrologic conditions and water needs elsewhere in the basin may preclude always achieving the guide curve.	Section 6.1.1.1.3
WM70	The USACE has ignored the adverse impacts of agricultural demand on the Flint River basin which has been stressed by agricultural uses during dry weather. Subsidizing lost flows to the Apalachicola from the Flint basin due to dry weather and agricultural use is not and never has been an authorized purpose of any USACE project on the ACF system.	The impacts of water used for agricultural purposes will be considered and described in the EIS.	Section 2.1.1.2; Section 4.1; Section 6 Appendix E
WM71	The USACE should not reduce flows in the Chattahoochee River when Flint River inflow is sufficient to meet requirements for the Apalachicola River. Minimum flows in the Chattahoochee River should be maintained.	The EIS will consider alternative Basin Inflow measurement procedures.	Section 4.1.2.7
WM72	The USACE should consider the alternative operations proposed in the Tri Rivers Waterway Development Association's report. The report identifies reservoir management rules that would result in flow regimes that would improve navigation flows in the Chattahoochee River and environmental flows in the Apalachicola River, with manageable and minimal impacts to users in the upper basin. The USACE should maintain lake levels under normal conditions of 632.3 to 635 msl at West Point Lake; 187.5 to 190 msl at Lake Eufaula (Walter F. George); and 76.5 to 77.5 msl at Lake Seminole (Jim Woodruff) when possible.	The management plan described by the Tri-Rivers Water Development Association will be considered in the EIS.	Section 4.1; Section 4.2
WM73	George W. Andrews Lock and Dam and Lake should be listed for water supply purposes.	Water supply is not an expressly authorized purpose of the George W. Andrews Lock and Dam and Lake.	Section 2.1.1.1.6; Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
Socioeconomics and Recreation (SR)			
SR1	Develop an economic study on the impact of various water levels on each region of the ACF Basin.	The EIS will consider the economic impact of water management alternatives.	Section 6.5; Appendix L
SR2	Low lake levels at Lake Lanier have a devastating effect on local economies.	The EIS will consider the economic impact of water management alternatives.	Section 6.5; Appendix L
SR3	The loss of recreational facilities, coupled with consistently low lake levels, has adversely affected the recreational potential of West Point Lake and its economic benefit!	The USACE will consider recreational impacts in the update of the WCM.	Section 6.5.6; Appendix L
SR4	The use of West Point Lake to support downstream navigation should not be considered in any alternative in operation plans without adequate study of the ecological and other environmental damages caused by the likely lake fluctuations to support that activity.	Changes to West Point Lake action zones will be considered as part of the update of the WCM. The environmental impacts of water management alternatives will be evaluated in the EIS. Navigation is one of the congressionally authorized purposes of West Point Lake and the ACF system of federal projects, and must be considered in making operational decisions.	Section 4.1
SR5	West Point Lake must be maintained at a minimum of 633 ft to maintain economic growth in this area and Georgia.	Changes to West Point Lake action zones will be considered as part of the update of the WCM. Any considered water management alternative should maintain at least the current level of flood risk management. Additionally, this suggestion could pose risks to the structural integrity of the project, could pose risk to public safety of the facility or downstream of the project, and could affect the availability of flows to comply with the USACE's obligations under the ESA.	Section 6.5
SR6	Lake Lanier is a recreational resource that generates 8 million visits per year resulting in an economic impact of $5.5 billion to the regional economy.	The USACE will consider recreational impacts in the update of the WCM.	Section 6.5.6; Appendix L
SR7	The USACE must manage Lake Lanier and West Point Lake to maintain lake levels to meet their authorized recreational uses and support the recreation-based economies.	The ACF projects were designed as multi-purpose storage reservoirs and are operated as such. The EIS will consider the economic impact of water management alternatives.	Section 6.5.6; Appendix L
SR8	The EIS needs to consider the economic value of the ACF Basin and evaluate the socioeconomic, recreational, and safety impacts of fluctuating and low water levels in the ACF Basin. Assess the adverse impact of low water levels on the local businesses, property values, taxes, and boat docks.	The USACE will consider recreational impacts in the update of the WCM.	Section 6.5.6; Appendix L

Number	Scoping Comment	USACE Response/Action	EIS Reference
SR9	The 5,000 cfs minimum flow at the Chattahoochee Gage is not legally required and is unsustainable in the long run without substantial harm to recreation.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of Jim Woodruff Dam. On the basis of that consultation a revised minimum flow might be established at Jim Woodruff Dam.	Section 4.1.2.8.7; Section 6.4.3
SR10	The EIS should identify, analyze and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations per Executive Order 12898 (Environmental Justice).	In updating the WCM, USACE will comply with all applicable legislation, regulations, and Executive Orders.	Section 6.5.8
SR11	The WCM should review new and innovative procedures to enhance warning systems to improve public safety and recreation throughout the ACF system.	This suggestion would not be within the scope of the proposed federal action, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin. Current practices are summarized in the EIS.	Section 6.5.7.1
SR12	Rapid changes in flow below Buford Dam in the CRNRA pose a safety risk to boaters, rowers, anglers, and waders. Include a sensitivity study based on reducing Buford Dam's discharge peaks while maintaining the historical daily average power generated.	Buford Dam is authorized and designed as a peaking hydropower facility. Safety measures have been implemented to warn anglers downstream of Buford Dam when peaking operations are beginning.	Section 6.1.1.2.1; Section 6.5.7.1
SR13	The social and economic costs associated with property loss and bank stabilization efforts are an emerging issue in communities along the Chattahoochee River. In evaluating alternatives for the operation of Buford Dam, the EIS should consider the future impacts of bank erosion and the growing cost of measures taken to protect private and public property and facilities.	USACE is not conducting a bank stabilization study or project. Such a study or project would be beyond the scope of the federal action. Accordingly, such a measure does not meet the purpose and need of tis EIS, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law. The environmental effects of the WCM update on bank erosion will be considered in the EIS.	Section 1.3; Section 4.1; Section 6.2
SR14	The USACE's EIS needs to evaluate the possibility of supplemental Buford Dam releases to support weekend recreational activities and enhance the recreational values envisioned by Congress when CRNRA was established.	The USACE will consider measures and alternatives that could affect releases from and flows below Buford Dam. However, the authorized purposes of the ACF system do not include specific flow requirements within the CRNRA.	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
SR15	The USACE should include the flow needs for the Chattahoochee River Aquatic Ecosystem Restoration and Whitewater project in the WCM update. The project is designed for a minimum flow of 800 cfs but needs flows of up to 3,000 to 5,000 cfs to provide for optimum recreational opportunities.	The USACE participated in constructing the Chattahoochee River Aquatic Ecosystem Restoration and Whitewater project. The USACE's minimum flow requirement from West Point Dam is 675 cfs, and the authorized purposes of the ACF system do not include operating the West Point project to ensure a particular flow regime at Columbus, Georgia.	Section 4.1
NEPA Process (NEPA)			
NEPA1	The appropriate baseline for the USACE NEPA analysis is the "run-of-river" flow regime, which assumes the dams are in place but that the reservoirs simply release the water as it comes in without storing any of it for release later.	The ACF projects were designed as multipurpose storage reservoirs and are operated as such. Therefore matching outflow to inflow violates reservoir operating principles, is not technically feasible, and would not allow all project purposes to be met. In updating the WCM, the USACE will assess different operating schemes, and include assessment of drought operations.	Section 2.1.1.2; Section 4.3
NEPA2	The appropriate baseline for the USACE NEPA analysis is the historical flow conditions (pre-ACF federal and pre-non-federal dams and reservoirs) of the Apalachicola, Chattahoochee, and Flint rivers as the baseline, with particular attention to the historical flow regime of the Apalachicola River.	The purpose and need of this EIS is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 2.1.1.2; Section 4.3; Section 5.2.1
NEPA3	The appropriate baseline for the USACE NEPA analysis one based on the existing ACF manual promulgated in 1958.	The original 1958 Master WCM does not include project WCMs for Buford Dam or for West Point Dam, Walter F. George Lock and Dam, or George W. Andrews Lock and Dam, all of which were completed later. For that reason, the 1958 manual cannot be used as a baseline. The individual reservoir project WCMs were completed as projects were constructed and placed into operation. When approved, the project-specific manuals were attached as appendices to the 1958 Master WCM. A draft update to the main body of the 1958 Master WCM for the ACF Basin was prepared in 1989 and incorporated several operational adjustments, primarily focusing on adjustments gathered through experience and lessons learned during severe drought periods in the 1980s. Since 1989, the ACF projects have been operated in accordance with the draft WCM.	Section 2.1.1.2; Section 4.3; Section 5.2.1
NEPA4	The EIS must identify and set a baseline for the change in operations when water supply became a project purpose at Lake Lanier because the 11th Circuit has delineated that storage could be used for downstream.	Same as WM12	Section 2.1.1.2; Section 4.3; Section 5.2.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
NEPA5	The correct baseline at Lake Lanier for purposes of performing the trigger analysis is the amount of storage originally allocated to water supply at Lake Lanier, which is zero.	The NEPA no-action alternative reflects current operations, and the USACE will also evaluate an alternative that involves no reallocation of storage in Lake Lanier for water supply. Refer to WM12.	Section 2.1.1.2; Section 4.3; Section 5.2.1; Appendix B
NEPA6	The appropriate baseline should be continuing existing operations. This would include continued operations under the USACE's RIOP, as addressed in the USFWS's May 2012 biological opinion, and existing levels of water supply withdrawals.	The NEPA no-action alternative reflects existing operations, including current levels of water supply withdrawals. In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of the ACF Basin. The USACE will consider a range of measures when updating water control plans and manuals to achieve congressionally authorized purposes of projects in the ACF Basin, taking into account the needs of the entire basin and complying with the requirements of the ESA. The water supply storage assessment prepared as part of the EIS will consider alternative levels of water supply.	Section 2.1.1.2; Section 4.3; Section 5.2.1; Appendix B
NEPA7	To establish the proper baseline, the Draft EIS should document and evaluate the historical changes in the ACF Basin with respect to the following indicators: historical flows (i.e., the pre-dam and reservoir flow regimes), including the amount, timing, and quality of flows in the ACF rivers; acres of river and floodplain wetlands lost; acres of native upland habitats lost; miles of streambed lost or modified; changes in stream flows; changes in ground water elevations; changes in the concentrations of indicator water quality constituents; changes in the abundance, distribution, and diversity of indicator fish communities; and changes in rainfall, and reasonably foreseeable future changes.	Because the proposed federal action is to update the ACF WCM to reflect congressionally authorized purposes for federal projects that actually exist, in light of current conditions and applicable law, it would not be appropriate to use pre-project conditions as a baseline for evaluating alternatives.	Section 2.1.1.2; Section 4.3; Section 5.2.1; Appendix B
NEPA8	The impact analysis should be based on comparing the simulated inflows to Apalachicola River with the actual (observed) flows at the U.S. Geological Survey (USGS) Chattahoochee streamflow station on the Apalachicola River.	Impact analyses performed for the EIS will utilize HEC-ResSim which simulates the effects of changing individual and multiple operational measures at individual reservoirs and across the entire ACF Basin. It is not appropriate to try to compare model results to actual gage measurements due to the variety of "real world" influences that cannot be modeled.	Section 4.1 Section 6 Appendix E

Number	Scoping Comment	USACE Response/Action	EIS Reference
NEPA9	The USACE needs to define the performance measures used to evaluate alternatives in the EIS, explaining the criteria or performance metrics used to compare alternatives and to ultimately decide which approach is recommended.	The EIS will identify performance measures and display impacts of alternative project operations on a variety of resources.	Section 6
NEPA10	The USACE NEPA analysis must evaluate direct, indirect, and cumulative impacts. Cumulative impacts would include the proposed Glades Farm reservoir in Lake Lanier's headwaters, the proposed Bear Creek Reservoir in South Fulton County, Bartletts Ferry hydroelectric (FERC) relicensing, and Georgia's regional water planning efforts.	The EIS will consider the planning efforts of others and will address the cumulative effects of the proposed federal action and other reservoirs being considered within the ACF Basin.	Section 6
NEPA11	The USACE must assess the magnifying and additive effects of climate change and global warming when evaluating the direct, indirect, and cumulative impacts of a particular flow regime for the ACF system.	The EIS will consider climate change and cumulative effects.	Section 6.8; Section 6.9
NEPA12	USACE should initiate an evaluation of the ecological flows needed to protect and restore the chemical, physical, and biological integrity of the ACF Basin and the species that rely on those waters and consider a full range of alternatives that will ensure the maintenance of those ecological flows. The USACE will also evaluate impacts of the proposed action and alternatives on water quality and fish and wildlife.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 4.1.2.8; Section 4.1.3.5; Section 6.4; Appendix J
NEPA13	USACE should update and correct the unimpaired flow data set and the water demand data currently be used by the USACE for its modeling and analysis; (b) establish the sustainable limits of water use in the basin; (c) re-evaluate evaporative losses, including particularly the evaporation that occurs during droughts; and (d) evaluate any ongoing or completed ecological flow evaluations being conducted for rivers within the ACF system.	The unimpaired flow dataset will be extended through 2012 and coordinated with the three states prior to finalization and will include an evaluation of evaporative losses. The dataset will be input to the HEC-ResSim model to evaluate the effects of proposed water management alternatives and Georgia’s 2013 water supply request. In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 6 (introduction) Section 6.4.3 Appendix E Appendix J
NEPA14	The purpose and need for the EIS should include meeting Georgia's current and future water supply needs. Georgia's full water supply request should be an action alternative. The USACE should evaluate the economic benefits of granting the request and fully consider the indirect effects of granting anything less than the full water supply request.	The EIS will address and consider alternatives to accommodate Georgia’s 2013 water supply request.	Section 5.1; Appendix B

Number	Scoping Comment	USACE Response/Action	EIS Reference
NEPA15	Structural alternatives (including either closing or installing a lock at Sikes Cut, restoring the channel below Woodruff Dam, refurbishing the intake at Plant Farley, and renovating projects to reduce releases necessitated by head limits) should also be evaluated and considered.	Such proposals do not meet the purpose and need to determine how the existing federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 4.1.1
NEPA16	The USACE should include in its WCM development: evaluation of alternative levels for the rule curves and action zones in the ACF projects; reconsideration of its policy of balancing the volume of water stored among the reservoirs based on percent of action zone; reconsideration of Woodruff Dam release requirements, including minimum flows; and the development of forecast based operating rules which can improve the benefits derived from reservoir operating rules for all purposes.	The EIS will consider modifications to guide curves and action zones at the ACF projects in the interest of better meeting all authorized project purposes. However, any considered water management alternative should maintain at least the current level of flood risk management.	Section 4.1
NEPA17	The FERC Middle Chattahoochee Project License (P-2177-053) flow regimes should be part of the new ACF WCM.	USACE is aware of GPC's relicensing process for their Middle Chattahoochee Project. The WCM update will consider the provisions of the current FERC license. Until FERC issues a new license, it is premature to consider what the provisions of that license might be.	Section 2.1.1.1.6.4
NEPA18	The NEPA analysis should consider the cumulative impacts of these revisions on water stress in the basin (e.g. a list of all permitted/proposed reservoirs in the basin); an explanation of how provisions in the WCM interact with state water planning and withdrawal permitting would be informative; the WCM should account for, to the extent practicable, future predicted trends in inflows (e.g., long term decreases in base flow corresponding to increased evapotranspiration, consumptive uses or impervious surface); and the likelihood of future trends in reuse (industrial reuse, gray water, direct or indirect potable reuse), particularly in the greater metropolitan Atlanta area, should be discussed.	The EIS will consider the planning efforts of others and will address the cumulative effects of the proposed federal action and other reservoirs being considered within the ACF Basin.	Section 2.1.1.2; Section 6.9

Number	Scoping Comment	USACE Response/Action	EIS Reference
Biological Resources (BR)			
BR1	The management plan must restore and maintain ecological flows to protect and restore the entire ACF system, not just Lake Lanier, and the EIS should evaluate impacts on the entire ACF system.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species. The USACE will comply with all applicable legislation, regulations, and Executive Orders and will evaluate impacts of the proposed action and alternatives on water quality and fish and wildlife.	Section 4.1; Section 6.4.3
BR2	USACE guidance requires the establishment of the minimum stream flow needed to address water quality, fish and wildlife, recreation, and aesthetic considerations when developing WCMs, even where maintenance of minimum in-stream flows is not an authorized project purpose.	In updating the WCM, USACE will comply with all applicable legislation, regulations, and Executive Orders.	Section 6; Table 6-1
BR3	The EIS for the revised WCM should evaluate the impacts on Apalachicola River and Bay.	The USACE will use available data to consider the direct, indirect, and cumulative impacts of the proposed action in the EIS. However, the Apalachicola River below the intersection with the Gulf Intracoastal Waterway and the Apalachicola Bay are not part of the federal ACF system.	Section 6.4.2.3 Section 6.9
BR4	Adverse environmental and economic effects of upstream population growth and ACF management measures (in particular low flow) on Apalachicola River and Bay need to be evaluated and corrected.	As part of the Fish and Wildlife Coordination Act Report, the USFWS conducted hydrodynamic modeling of the Apalachicola Bay to assess the effects of alternative operations on salinity regimes. The USACE will use those data to consider the direct, indirect, and cumulative impacts of the proposed action in the EIS.	Section 6.4 Appendix J
BR5	The USACE should apply a spatially explicit hydrodynamic model of Apalachicola Bay to assess the effects of alternative operations on salinity regimes, and in turn, on the relative distribution of salt marshes, submerged grass beds, and oyster bars in the bay.	Refer to BR4.	Section 6.4 Appendix J
BR6	The EIS needs to address that productivity of the Apalachicola Bay is being adversely affected by a lack of nutrient input from the backswamps upriver because, in the absence of sufficient mainstem flows, these areas have not experienced in several years their typical winter flood cycle. Thus, nutrients produced in the remarkably large and intact bottomland hardwood forests which buffer the Apalachicola River are not being transported to the bay.	Refer to BR4. Additionally, the EIS will consider the frequency of Apalachicola River floodplain inundation in evaluating performance of alternative	Section 6.4 Appendix J

Number	Scoping Comment	USACE Response/Action	EIS Reference
BR7	The USACE should update reservoir fisheries performance measures in light of any new information developed in the past 10 years and use it to evaluate the relative impacts on reservoir sport fisheries of alternative operating plans.	Limited recent data required the USACE to use the reservoir fisheries performance measures developed during the comprehensive study.	Section 6.4.2.2
BR8	The USACE should perform an environmental study to determine how much water the federally listed threatened and endangered species of mussels need during drought conditions to survive.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 6.4.3; Appendix J
BR9	The USACE should operate projects in the ACF Basin to mimic a natural flow regime.	The USACE will consider alternatives to current operations. However, the purpose and need of the proposed federal action is to update the WCM to determine how the federal projects in the ACF Basin should be operated for their congressionally authorized purposes, in light of current conditions and applicable law, rather than to restore the ACF Basin to pre-project conditions. Any reasonable alternative must satisfy that purpose and need.	Section 4.1.1 Section 4.1.2
BR10	The WCM should include operations for endangered species that more fully integrate all water storage projects in the ACF Basin rather than relying almost exclusively on Lake Lanier.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 4.1; Section 6.4.3
BR11	The USACE should evaluate the relative impacts on reservoir sport fisheries of alternative operating plans.	The EIS will consider the effects of proposed water management changes on reservoir fisheries.	Section 6.4.2.2
BR12	The USACE should continue to manage reservoir water levels to maintain the fish spawn period of four to six weeks within an eight-week window and continue to support and facilitate fish passage via conservation locking at Jim Woodruff Lock and Dam.	The EIS will consider continuation of existing fishery management measures.	Section 6.4.2
BR13	The USACE needs to evaluate the impacts of extreme fluctuations in West Point Lake levels on the lake's water quality from erosion and siltation, and the resulting impacts on fish spawn (bass, crappie) and mussels and other wildlife, the increased the cost of water treatment, and lost water storage.	The EIS will consider the effects of alternatives on the potential shoreline erosion and sedimentation.	Section 6.4.2.2
BR14	The EIS needs to take into account the impact of USACE operations in the basin on the Eufaula National Wildlife Refuge (ENWR).	The EIS will consider impacts of water management alternatives on the ENWR.	Section 4.1; Section 6.4.4

Number	Scoping Comment	USACE Response/Action	EIS Reference
BR15	The Draft EIS should evaluate opportunities for varying discharges from Buford Dam to support a broad range of species within CRNRA, including shoal bass and other native species.	Key flow requirements downstream of Buford Dam will be recognized in the updated WCM and EIS. However, the authorized purposes of the federal ACF system do not include specific flow requirements in the CRNRA.	Section 4.1.1 Section 4.1.2
BR16	The USACE should evaluate potential impacts of water temperature and dissolved oxygen levels and bank sloughing below Buford Dam on the hatchery operation and the sport fishery for both stocked and naturally reproducing trout in the Chattahoochee River upper river reach, as well as the entire ACF Basin. The hatchery and fishery are dependent upon cold water and high dissolved oxygen levels which need to be maintained.	The EIS will address the impact of the proposed action and alternatives on water quality and fish and wildlife.	Section 6.4.4.2
BR17	USACE analysis should examine an approach setting a percent reduction limit on the area of connected aquatic floodplain habitat to inform their percent-of-flow reduction recommendations.	Minimum flow provisions adequately address floodplain connectivity.	Section 4.1.2.8.5; Section 4.1.3.5.3; Section 6.4.2.1
BR18	USACE should consider pulse flows in the Apalachicola River during the non-spawning season (June through November).	USACE will consider pulse flows in the Apalachicola River.	Section 4.1
BR19	USACE should examine the indirect effects of its management of the ACF system on water levels in the Oconee-Ocmulgee-Altamaha and Alabama-Coosa-Tallapoosa river systems, since there are a number of interbasin transfers taking place among these systems around metro Atlanta.	Examining the effects of interbasin transfers on the Oconee-Ocmulgee-Altamaha and Alabama-Coosa-Tallapoosa river systems would not be within the scope of the proposed federal action, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin. USACE is aware of certain interbasin transfers currently occurring and will take that data into account in ResSim modeling.	Section 2.1.1.2; Section 4.1.1; Appendix E
BR20	USACE should consider revising ramping rates at Jim Woodruff Dam. Maximum fall rates and flow support for Woodruff Dam releases greater than 5,000 cfs are suspended when storage declines to Zone 4, and resumed when storage returns to a specified zone (“drought relief end zone”); when flows at Woodruff Dam have been less than 7,000 cfs for more than 30 days, maximum fall rates be suspended and resumed when flows have been greater than 10,000 cfs for 30 days.	USACE will consider alternative procedures for determining fall rates.	Section 4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
BR21	USACE should consider establishing seasonal flow targets for releases to the Apalachicola River.	USACE will consider alternative procedures for determining flows to be released into the Apalachicola River.	Section 4.1
BR22	USACE should consider monthly flow targets for the Apalachicola River.	USACE will consider alternative procedures for determining flows to be released into the Apalachicola River.	Section 4.1
BR23	USACE is encouraged to continue consultation with USFWS to explore opportunities for greater system storage retention via lowering *target* flows to more closely match *minimum* flows, especially in composite zones 1 and 2, with potential to also extend spring/summer release periods to improve likelihood of achieving 30-day+ periods of flood plain inundation.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 4.1; Section 6.4.3; Appendix J
Drought Operations (DO)			
DO1	Better management triggers should be in place for Lake Lanier withdrawals during times of drought.	The update of WCM will include development of a drought operations plan.	Section 4.1
DO2	Decrease the winter draw down level on all reservoirs to reduce the impact of drought conditions.	In updating the WCM, the USACE will consider guide curve changes at ACF Basin projects.	Section 4.1
DO3	The effect of drought should be shared equally among the states.	The update of WCM will include development of a drought operations plan that balances project operations of all ACF projects.	Section 4.1
DO4	Do not release water from Lake Lanier for downstream purposes during a drought.	The USACE will develop a revised drought operations plan as part of the WCM update. The plan will guide releases from Lake Lanier during drought. It should be noted that the proposed measure, if implemented, would violate systems-operations criteria.	Section 4.1
DO5	Include emergency drought measures in the operational manual.	The update of WCM will include development of a drought operations plan.	Section 4.1
DO6	We must hold back as much water as possible in Lake Lanier during drought times. Water supply is the highest need.	The USACE will develop a revised drought operations plan as part of the WCM update. The plan will guide releases from Lake Lanier during drought and consider all authorized project purposes.	Section 4.1
DO7	Drought contingency plans should be formally coordinated with dischargers (especially NPDES permit holders) and water intake permittees (including public drinking water suppliers, cooling water intakes, industrial users, etc.).	Draft WCMs, including a drought management plan, and the draft EIS will be made available to the public, including dischargers, for review and comment.	Section 4.1; Section 6.1.2

Number	Scoping Comment	USACE Response/Action	EIS Reference
DO8	The USACE NEPA analysis should consider whether emergency conservation measures and/or reallocating more of the composite conservation storage to West Point Lake and the other downstream reservoirs could better alleviate adverse drought impacts.	The EIS will consider modifications to guide curves and action zones at the ACF projects in the interest of better meeting all authorized project purposes.	Section 4.1
DO9	We recommend that the USACE consider how climate change could affect ACF Basin flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes.	The EIS will consider climate change.	Section 6.8; Appendix M
Water Quality (WQ)			
WQ1	The WCM update process should also evaluate the USACE's compliance with existing environmental laws, as a new federal and state laws and regulations have been enacted since the USACE reservoirs in the basin were constructed.	In updating the WCM, USACE will comply with all applicable legislation, regulations, and Executive Orders.	Section 3.6 Section 6 (introduction)
WQ2	Discussion of best management practices for sediment and stormwater management in the system should be central to the WCM analysis of lake operations.	The USACE will use available data to consider the direct, indirect, and cumulative impacts of water management alternatives on shoreline erosion in the EIS. With regard to activities on non-Government owned lands, this suggestion would not be within the scope of the proposed federal action, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	
WQ3	The USACE should analyze the effects of the WCM operations on water quality standards, with a particular emphasis on physiochemical endpoints such as dissolved oxygen, biological endpoints such as sensitive aquatic species, and physical endpoints that protect the designated aquatic life use, including adequate flows to maintain the physical integrity of the habitat.	Water quality management and control of point and nonpoint sources of pollution off USACE project lands is principally the responsibility of the states. In accordance with ER 1110-2-8154, the USACE has an objective to ensure that water quality, as affected by a USACE project and its operation, is suitable for project purposes, existing water uses, and public safety, and is in compliance with applicable federal and state water quality standards. Water quality will be taken into account when updating water control plans and manuals. Under the Water Pollution Act of 1972 as amended, states (not USACE) establish water quality standards and are responsible for ensuring that wastewater discharges meet those standards.	Section 6.1.2

Number	Scoping Comment	USACE Response/Action	EIS Reference
WQ4	Examine the effects of reservoir operations on water quality.	Water quality management is primarily the responsibility of the states. In accordance with ER 1110-2-8154, the USACE has an objective to ensure that water quality, as affected by a USACE project and its operation, is suitable for project purposes, existing water uses, and public safety, and is in compliance with applicable federal and state water quality standards. Water quality will be taken into account when updating the WCM.	Section 6.1.2
WQ5	The USACE should ensure that releases from all five ACF dams meet or exceed DO [dissolved oxygen] and other water quality standards.	Refer to WQ4.	Section 6.1.2
WQ6	The USACE should formulate a protocol with the Georgia Department of Natural Resources Wildlife Resources Division (GA DNR WRD) for special releases from Buford Dam to mitigate warm water runoff on the Buford Trout Hatchery.	Refer to WQ4.	Section 2.1.2.1 Section 6.4.4.2 Appendix A
WQ7	The USACE should evaluate the 750 cfs operational flow criteria at the Chattahoochee River below the Atlanta withdrawal point, in light of current permit requirements and assimilative capacity to determine whether alternatives to that flow may exist.	Under the Water Pollution Act of 1972 as amended, states (not the USACE) are authorized to establish water quality standards and are responsible for ensuring that wastewater discharges meet those standards.	Section 4.1
WQ8	Constant fluctuation of lake levels to accommodate flood control and the RIOP could be damaging the ecosystem and water quality in West Point Lake.	The effects of considered water management changes on water quality and environment in West Point Lake will be taken into account when updating the water control plans and manuals.	Section 4.1; Section 6.1.2; Appendix K
WQ9	The USACE should consider operational or design criteria to improve DO conditions in the West Point Dam tailwater especially during summer months and a DO study of the tailwater needs to be conducted.	The effects of considered water management changes on water quality in West Point Lake will be taken into account when updating the water control plans and manuals. The USACE will also comply with all provisions of the Water Pollution Act of 1972 as amended that apply to USACE-operated dams.	Section 4.1.1; Section 6.1.2; Appendix K
WQ10	The USACE ACF WCM should support GA DNR's thermal management of the Chattahoochee River Tailwater, with water temperature not exceeding 22°C maximum or 20°C as a 5-day average more than once in 30 days measured by USGS Gauge 02335450 at Eves Road.	Refer to WQ4.	Section 6.1.2; Appendix K

Number	Scoping Comment	USACE Response/Action	EIS Reference
WQ11	The USACE WCM should include operational measures for releases from Buford Dam to be managed to minimize erosion from bank-sloughing. The environmental effects of severe bank undercutting and erosion include increased siltation, which leads to long-term habitat alterations that may negatively impact aquatic species. The EIS should evaluate the impact of dam operations on organisms that benefit from a gravel or rocky substrate, including trout, shoal bass, mussels, and macroinvertebrates (which has been noted above Morgan Falls Dam). Increasing sediment in Bull Sluice Lake has created a shallow water body optimal for the growth of exotic aquatic plant species.	The USACE will use available data to consider the direct, indirect, and cumulative impacts of water management alternatives on shoreline erosion in the EIS.	Section 4.1.1; Section 6.1.2; Appendix K
WQ12	If dam operations are modified to institute or accommodate lower base flows, water quality within CRNRA would likely deteriorate due to a reduction in the positive influence of clean water released from Buford Dam.	In accordance with ER 1110-2-8154, USACE has an objective to ensure that water quality, as affected by a USACE project and its operation, is suitable for project purposes, existing water uses, and public safety, and is in compliance with applicable federal and state water quality standards. Water quality will be taken into account when updating the WCM.	Section 6.1.2; Appendix K
WQ13	USACE must operate West Point Lake in a manner that assures compliance with the Water Pollution Act of 1972 as amended.	The effects of considered water management changes on water quality in West Point Lake will be taken into account when updating the WCM. The USACE will also comply with all provisions of the Water Pollution Act of 1972 as amended that apply to USACE-operated dams.	Section 6.1.2; Appendix K
WQ14	Ensure that water treatment releases up river [from West Point Lake] meet or exceed federal standards.	The effects of considered water management changes on water quality in West Point Lake will be taken into account. Under the Water Pollution Act of 1972 as amended, states (not the USACE) are authorized to establish water quality standards and are responsible for ensuring that wastewater discharges meet those standards.	Section 6.1.2; Appendix K
WQ15	Water quality in West Point Lake should meet recreational use standards.	Refer to WQ4.	Section 6.1.2; Appendix K
WQ16	Water quality and water supply should be at the top of the priority list when considering West Point Lake.	Refer to WQ4. The USACE does not prioritize project purposes. Water quality and water supply (relocation agreement for the city of LaGrange) will be taken into account when updating the WCM.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WQ17	Study the effects of the RIOP on water quality at West Point Lake.	The effects of considered water management changes, including drought operations, on water quality in West Point Lake will be taken into account when updating the water control plans and manuals.	Section 4.1; Section 6.1.2; Appendix K
WQ18	Adopt a Permanent Water Quality Minimum Flow of 650 cfs at Peachtree Creek.	Under the Water Pollution Act of 1972 as amended, the State of Georgia through the Environmental Protection Division (not the USACE) establishes water quality standards and is responsible for ensuring that wastewater discharges meet those standards. USACE will take into account in the EIS minimum flows established by the state.	Section 4.1
WQ19	USACE should consider a monthly flow target at Peachtree Creek.	Refer to WQ18.	Section 4.1
WQ20	Eliminate the mandatory requirement for 5,000 cfs at Woodruff Dam.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the operations of Jim Woodruff Dam. On the basis of that consultation a revised minimum flow might be established at Jim Woodruff Dam.	Section 4.1
WQ21	Apalachicola Bay is being affected.	The USACE will use available data to consider the direct, indirect, and cumulative impacts of the proposed action in the EIS.	Section 6.4.2; Section 6.9
WQ22	Conduct a scientific analysis of the fresh water needs and salt water tolerances of the Apalachicola Bay.	As part of the Fish and Wildlife Coordination Act Report, the USFWS conducted hydrodynamic modeling of the Apalachicola Bay to assess the effects of alternative operations on salinity regimes. The USACE will use those data to consider the direct, indirect, and cumulative impacts of the proposed action in the EIS.	Section 6.4.2; Section 6.9; Appendix J
Water Supply (WS)			
WS1	Maintain appropriate lake levels in West Point Lake to provide for drinking water.	Past USACE water management practices have kept West Point Lake water levels above water supply relocation agreement intake elevations. When updating the WCM, the USACE will take into account the water supply at West Point Lake (relocation agreement for the city of LaGrange).	Section 6.1.1.5.2; Section 6.5.1.2
WS2	Water quality and water supply should be top priorities at West Point Lake.	Refer to WQ16.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
WS3	In assessing all alternatives in the EIS, the USACE must take into account Georgia's future water supply needs. Georgia believes that 705 mgd will be sufficient to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040.	The water supply needs of the region have been described in a request made by the State of Georgia on January 11, 2013. A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier.	Section 5.1; Appendix B
WS4	Any EIS alternatives that do not involve releases to support up to 408 mgd of withdrawal from the Chattahoochee River above the Peachtree Creek confluence and 297 mgd withdrawal from Lake Lanier by 2040 must account for the economic, environmental, and sociological effects of other water projects that the State or local water systems will have to develop to meet the shortfall.	Refer to WS3.	Section 5.1; Appendix B
WS5	Water supply is the highest and best use of storage in Lake Lanier.	Refer to WM12.	Section 5.1; Appendix B
WS6	Water supply should be the top priority at Lake Lanier.	Refer to WM12.	Section 5.1; Appendix B
WS7	Maintain lake levels at Lake Lanier above water supply intake elevations.	Past USACE water management practices have kept Lake Lanier water levels above water supply relocation agreement intake elevations. Intakes at Lake Lanier constructed pursuant to relocation agreements for the cities of Buford and Gainesville will be taken into account when updating the WCM.	Section 6.1.1.5.1; Section 6.5.1.1
WS8	Reduce the flow target at Peachtree Creek to 650 cfs (during droughts) to preserve water supply storage in Lake Lanier.	The USACE is not required to operate to meet that flow target. Under the Water Pollution Act of 1972 as amended, the State of Georgia through the Environmental Protection Division (not the USACE) establishes water quality standards and is responsible for ensuring that wastewater discharges meet those standards.	Section 4.1.2.4;
WS9	Pipe desalinated water from the Atlantic to Atlanta.	Refer to WS3. This analysis will consider alternatives to reallocating storage in Lake Lanier.	Section 5.1; Appendix B
WS10	Use West Point Lake to provide drinking water to Atlanta.	A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier. Various alternatives to reallocation of storage from Lake Lanier to satisfy these needs will be considered.	Section 5.1; Appendix B
WS11	During the rainy season, allow Lake Lanier to reach full pool no later than June 1 of each year.	The current guide curve for Lake Lanier provides for increasing the lake level to the summer pool elevation by May 1 each year.	

Number	Scoping Comment	USACE Response/Action	EIS Reference
WS12	Alternatives should consider long-term water supply needs and waste assimilation needs downstream.	The purpose and need for this action is to reflect current conditions and needs. The USACE analysis with respect to waste assimilation needs will consider permitted waste discharge loads. However, the USACE does not operate to accommodate waste assimilation needs except as required by dam minimum flow requirements contained in project authorizing documents.	Section 5.1; Appendix B
WS13	The USACE should consider the water supply needs of the region as identified in the Metropolitan North Georgia Water Planning District's long range plans.	Refer to WS3.	Section 5.1; Appendix B
WS14	Domestic water supply in the area of southeast Alabama will be a growing water-resource demand. The EIS must consider the municipal, industrial, and agricultural water-supply needs in the Alabama portion of the ACF Basin.	A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier. Forecasting water needs in other parts of the ACF Basin, however, is outside the scope of this EIS.	Section 4.1.1
WS15	Increasing demands (residential, commercial, industrial, agricultural) upon the water supply will require an infusion of water from outside the basin. This requirement must be evaluated in the USACE WCM update and EIS.	A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier. Forecasting water needs in other parts of the ACF Basin, however, is outside the scope of this EIS.	Section 5.1; Appendix B
WS16	In the WCM update, the USACE should consider storage enhancements in existing reservoirs and collaborating with Georgia Environmental Protection Division (GAEPD) and other stakeholders to develop a plan to improve return flows to accommodate growth and economic development.	The Water Supply Storage Assessment being prepared as part of this EIS will consider several alternative return rates based on current and potential future waste treatment infrastructure. Responsibility for returning wastewater to Lake Lanier is a local, not USACE, responsibility.	Section 5.1; Appendix B
WS17	The USACE should not assume that any direct withdrawals will be returned to Lake Lanier.	Refer to WS16.	Section 5.1; Appendix B
WS18	Instead of just including all of Atlanta's future water supply needs in the NEPA EIS models, the USACE should consider a range of Atlanta-area water-supply alternatives. These include much more aggressive conservation measures, desalination, and lower population growth for Metropolitan Atlanta, even if such measures are not within the USACE's jurisdiction.	Measures considered by various water users to reduce the consumption of water within the ACF Basin will be described in the EIS, to the extent that information is available to the USACE. Requiring the implementation of such measures, however, is generally a state and local responsibility, not a USACE responsibility.	Section 5.1; Appendix B

Number	Scoping Comment	USACE Response/Action	EIS Reference
WS19	The Douglasville-Douglas County Water and Sewer Authority (DDCWSA) is concerned that the update to the WCM may adversely impact the DDCWSA's 7Q10 requirements, necessitating additional releases from our small water supply reservoir(s) to the Chattahoochee River during periods of low flow. Such an impact could place additional demand on our potable water supply in drought periods.	The analyses conducted for the EIS will consider impacts on water quality of considered changes in water management procedures as well as options for satisfying the water supply needs of the Atlanta region.	Section 6.1.2
WS20	The DDCWSA is concerned that the WCM update may adversely impact the DDCWSA's future surface water withdrawal permits by reducing the permitted withdrawal amount or restricting the DDCWSA's ability to locate future withdrawals, further limiting DDCWSA's ability to provide water to the residents and businesses of Douglas County.	The EIS will consider current (2006) consumptive use patterns in the ACF Basin and the effects of this use on reservoir levels and streamflows using the HEC-ResSim model. Based on the June 2011 Circuit Court ruling, releases from Buford Dam for water supply in the Atlanta region is an authorized purpose. The EIS will address current and potential increases in downstream water needs.	Section 5.1; Appendix B
WS21	During times of drought when the DDCWSA's reservoir levels are low, and other times such as large water main breaks and other emergencies, the DDCWSA purchases water from the Cobb County-Marietta Water Authority (CCMWA) to help meet demand in Douglas County. The DDCWSA is concerned that the WCM update may adversely impact the CCMWA's allocated withdrawal capacity and therefore adversely impact the DDCWSA's water supply. This concern also applies to the DDCWSA's future water allocation from the CCMWA included in the MNGWPD Long-term Water Supply and Water Conservation Management Plan.	Refer to WS20.	Section 5.1; Appendix B
WS22	How will both consumptive use (withdrawals less returns) and in-stream or non-consumptive uses be addressed and the system managed in both wet and dry periods?	The EIS will consider current (2006) consumptive use patterns in the ACF Basin and the effects of this use on reservoir levels and streamflows using the HEC-ResSim model. A Water Supply Storage Assessment will be prepared addressing the water supply needs of communities currently withdrawing from Lake Lanier and the EIS will also consider the effects of potential increases in consumptive use.	Section 5.1; Appendix B
WS23	How will USACE define how returns are calculated, noting that not all users have accurate information about returns?	The Water Supply Storage Assessment being prepared as part of this EIS will consider several alternative return rates based on current and potential future waste treatment infrastructure.	Section 5.1; Appendix B

Number	Scoping Comment	USACE Response/Action	EIS Reference
WS24	The USACE should grant Forsyth County's request for a Lake Lanier drinking water withdrawal intake structure and storage allocation agreement.	Refer to WS3. Addressing Forsyth County's request for an intake structure is outside the scope of this EIS.	Section 5.1.1
WS25	Release little or no water from Lake Lanier during droughts.	The USACE will develop a revised drought operations plan as part of the WCM update. The plan will guide releases from Lake Lanier during drought.	Section 4.1
Data, Studies, and Analytical Tools (DS)			
DS1	Use the HEC-5 model rather than the HEC-ResSim model.	The USACE considered continued use of HEC-5 rather than HEC-ResSim for river system modeling, but it concluded that HEC-ResSim is the most current accepted reservoir modeling tool and has superior capabilities. Justification for model selection is presented in Appendix E, HEC-ResSim Modeling Report.	Section 4.1; EIS Appendix E
DS2	USACE should validate the HEC-ResSim model. The model has not been calibrated, no simulations have been made comparing the model results with observed data on reservoir levels or streamflow measured at USGS monitoring stations, and no sensitivity analysis or systematic error analysis have been performed.	Calibration of the HEC-ResSim model by comparing to observed flow and reservoir levels is not appropriate due to the variety of "real world" influences that cannot be modeled.	Section 4.1; EIS Appendix E
DS3	The USACE's *critical yield* methodology used to establish the baseline for future water allocations is inadequate and outdated and biased toward Atlanta-area interests. The methodology should look at the ecological flows needed to maintain the health and integrity of the ACF system.	The critical yield analysis of the ACF Basin will be revised during preparation of the WCM update and EIS (Appendix F, Critical Yield Analysis).	Section 2.1.1.2.9 EIS Appendix F
DS4	The USACE should include a study of the effects of reducing Buford Dam's discharge peaks on the stability of Chattahoochee water elevation at Morgan Falls Dam.	The EIS will consider the effects of water management alternatives on water levels at Morgan Falls.	Section 6.1.1.1.6; Section 6.1.1.2.2.1
DS5	The sections of the Chattahoochee River between impoundments need to be studied closely to determine the needs of the downstream ecosystems and the results of these studies should be used to establish flow requirements downstream of the Buford Dam that will maintain water quality (i.e., DO levels, minimize erosion and sedimentation).	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species.	Section 6.1.2 Section 6.4.2 Section 6.4.3 Appendix J
DS6	The USACE should evaluate the effects of a revised ACF WCM on Apalachicola River floodplain habitats.	The EIS will consider the effect of water management changes on Apalachicola River floodplain habitats.	Section 6.4.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
DS7	The USACE should evaluate the effects of a revised ACF WCM on the Apalachicola River's channel morphology because of altered flows and changes in operation, including bank erosion.	The effect of water management changes on channel morphology will be considered in the EIS.	Section 6.2
DS8	The USACE needs to review and update its water demands data and modeling data, including the unimpaired flow data set. The USACE needs to take into account recent shifts in rainfall and temperature patterns and evaporative losses in the ACF Basin and take advantage of new weather technology that is available, rather than relying on older, less representative data regarding basin conditions.	The unimpaired flow dataset will be updated. In updating the WCM, USACE will address climate change and include the most recent available data regarding basin conditions and best reliable forecasting services and technology.	Appendices A, E, and M;
DS9	The USACE should evaluate the effects of a revised ACF WCM on all relevant cumulative impacts, including depletions from irrigation pumping in the Flint River Basin and growth in the Metro Atlanta region; construction of new federal and non-federal reservoirs; and possible extended droughts because of long-term climate change.	The USACE's NEPA evaluation will consider cumulative effects.	Section 6.9
DS10	USACE's methodology for computing basin inflow creates a fundamental inequity between water for Georgia's consumptive water demands and releases of water into Florida for Apalachicola River and Bay. The updating of the WCMs should use the true hydrologic Basin Inflow for determining releases to Apalachicola River during non-drought periods.	The EIS will consider alternative Basin Inflow measurement procedures.	Section 4.1.2.7
DS11	USACE should determine Basin Inflow by tracking flow observed in the Apalachicola River at Chattahoochee, FL and adding considerations of storage change in Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole.	USACE will consider alternative Basin Inflow measurement procedures.	
DS12	The EIS should include a study of the impact of varying (including reducing) the Buford Dam peak discharge levels on turbidity and the related water treatment plant costs.	In accordance with ER 1110-2-8154, the USACE has an objective to ensure that water quality, as affected by a USACE project and its operation, is suitable for project purposes, existing water uses, and public safety, and is in compliance with applicable federal and state water quality standards. Water quality will be taken into account when updating the WCM. Determining turbidity effects on water treatment costs is outside the scope of this EIS.	Section 4.1.1; Section 6.1.2

Number	Scoping Comment	USACE Response/Action	EIS Reference
DS13	USACE should initiate an evaluation of the ecological flows needed to protect and restore the chemical, physical, and biological integrity of the ACF Basin and the species that rely on those waters.	In updating the WCM, the USACE will consult with USFWS under the ESA regarding the effects of operations on federally listed species and will comply with all applicable legislation, regulations, and Executive Orders. The USACE will evaluate impacts of the proposed action and alternatives on water quality and fish and wildlife.	Section 6.1.1.2; Section 6.1.2; Section 6.4; Appendix J
DS14	Pre-dam flows (unimpaired flows) should be used as the baseline to evaluate alternatives' effects on the Apalachicola River and Bay.	An unimpaired flow data set will be updated for use in the HEC-ResSim model. However, the USACE did not use the unimpaired flow data set as a baseline to analyze alternatives. The data set was used in coordination with the USFWS. Because the proposed federal action is to update the WCM to reflect congressionally authorized purposes for federal projects that actually exist, in light of current conditions and applicable law, it would not be appropriate to use pre-project conditions as a baseline for evaluating alternatives.	Section 4.1.1; Section 5.2.1; Appendix E
DS15	The WCM for the ACF Basin should include the reallocation of all the waters in the basin.	The USACE acknowledges that Alabama, Florida, and Georgia are in longstanding disagreement regarding the allocation of waters in the ACF Basin. While the USACE would, within the limits of applicable law and authority, seek to incorporate any tri-state agreement into its operation of federal projects in the ACF Basin, the allocation of waters among the states is not within the USACE's authority. Meanwhile, the USACE intends to implement the updated WCM for the ACF Basin of federal projects, in compliance with all applicable laws.	Section 1.3; Section 3; Section 4.1.1; Section 5.1.1
DS16	Effort must be expended to ensure that the most accurate and current data are used in modeling associated with the WCM updates rather than assuming than past data are accurate or that the accurate data can be obtained simply by asking the three states for data sets.	The USACE will endeavor to use the most accurate and current available data for modeling.	Section 4.1; Section 6; Appendices B, E, F, K, and M
DS17	The USACE's EIS has several analytical approaches in regards to hydropower with technical flaws and erroneous assumptions that need to be corrected.	The USACE will endeavor to use the most technically accurate analyses possible consistent with appropriate USACE guidance and policy.	Section 4.1; Section 6.5.3; Appendix B
DS18	The USACE should involve an outside technical peer review group to assure that the best data, information and approach are fed into the process and that an aura of objectivity is cast over the process.	The EIS will undergo Reviews in accordance with EC 1165-2-214, Civil Works Review, dated December 15, 2012.	Section 1.4

Number	Scoping Comment	USACE Response/Action	EIS Reference
DS19	The USACE should ensure that the ecological in-stream flow evaluation, the EIS, and the WCM are reviewed and assessed by the National Academy of Sciences pursuant to 33 U.S.C. § 2343(a)(3)(A)(iii).	The EIS will undergo Reviews in accordance with EC 1165-2-214, Civil Works Review, dated December 15, 2012.	Section 1.4
Other Resources (OR)			
OR1	The Mobile District should address and fully document the effects of the proposed action(s) on air quality.	The EIS will consider the impacts of proposed water management changes on air quality.	Section 2.7; EIS Appendix I
OR2	The Mobile District should address and fully document the effects of the proposed action(s) on cultural resources.	The Mobile District should address and fully document the effects of the proposed action(s) on cultural resources.	Section 6.6
OR3	The USACE's EIS should consider the impacts of rapidly fluctuating water levels on archeological and historic sites within CRNRA.	The EIS will consider the impacts of proposed water management changes on cultural resources.	Section 6.6
OR4	The USACE should take whatever measures are necessary to limit development along the shorelines of its lakes and the Chattahoochee River.	The USACE develops Shoreline Management Plans, which allocate a lake's shoreline into four categories—prohibited access areas, protected areas, public recreation, and limited development—and regulates uses and activities within those areas. That authority and responsibility does not extend to Chattahoochee River areas outside lands owned by the government or in easements to the USACE. Additionally, that alternative does not meet the purpose and need, which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin.	Section 4.1.1; Section 6.3
OR5	The USACE should do something about shoreline erosion at Lake Lanier.	The USACE will use available data to consider the direct, indirect, and cumulative impacts of the proposed action on shoreline erosion in the EIS.	Section 6.2
Navigation (NV)			
NV1	Revisions to the manual must recognize navigation as a primary project purpose and reflect statutory intent to support downstream communities.	The USACE recognizes that navigation is an authorized project purpose of the ACF system of USACE reservoirs, although the USACE does not rank project purposes within this multipurpose system. The update of the WCM will consider how to support navigation on the ACF system given the constraints in the Apalachicola River.	Section 1.3; Section 2.1.1.2; Section 4.1; Section 6.1.1.4; Section 6.5.2.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
NV2	Restore navigation for commercial and recreational purposes in the Middle Chattahoochee and Flint rivers. Consideration should be given to seasonal navigation that coincides with high spring releases for aquatic species.	The USACE recognizes that navigation is an authorized project purpose of the ACF system of USACE reservoirs. The update of the WCM will consider how to support navigation on the ACF system given the constraints in the Apalachicola River.	Section 4.1; Section 6.1.1.4; Section 6.5.2.1
NV3	USACE should augment Apalachicola River flows in the interest of navigation.	The update of the WCM will consider how to support navigation on the ACF system given the constraints in the Apalachicola River.	Section 4.1; Section 6.1.1.4; Section 6.5.2.1
NV4	The USACE should eliminate navigation as a project purpose on the ACF Basin.	This alternative does not meet the purpose and need which is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through an updated Master WCM of the ACF Basin. Navigation is one of the congressionally authorized purposes of the ACF system of federal projects and must be considered in making operational decisions.	Section 1.3; Section 2.1.1.2; Section 4.1.2.6
Hydroelectric Power (HP)			
HP1	Hydroelectric power is a high-priority project purpose.	The USACE recognizes that hydroelectric power is an authorized project purpose of the ACF Basin of USACE reservoirs, although the USACE does not rank project purposes in the multipurpose system. In updating the WCM, the USACE will consider all congressionally authorized purposes for the ACF Basin projects.	Section 4.1; Section 6.5.3; Appendix B
HP2	The updated WCM for the ACF Basin should not adversely affect the operation of a project with respect to the production of hydroelectric power.	The EIS will consider the effect of water management changes on hydroelectric power.	Section 4.1; Section 6.5.3; Appendix B
HP3	The USACE should include a sensitivity study based on reducing Buford Dam's discharge peaks while maintaining the historical daily average power generated. The study would include effects on the power system, public safety, recreation and transported sediment.	The EIS will consider the effect of water management changes on hydroelectric power, including the operation of Buford Dam as a peaking hydropower facility.	Section 4.1; Section 6.5.3; Appendix B
HP4	For purposes of developing the scope of the EIS, the loss of hydropower due to increased releases for downstream water supply for Atlanta should focus on the identification of the lost peak hydropower rather than a generalized decrease in energy production.	The EIS will include an analysis of the effects on peak hydropower of providing releases for downstream water supply as well as accommodating the water supply needs of communities currently withdrawing from Lake Lanier.	Section 4.1; Section 6.5.3; Appendix B

Number	Scoping Comment	USACE Response/Action	EIS Reference
HP5	The USACE calculations of hydropower impacts should refrain from limiting the analysis to lost energy on a project by project basis. Southeastern Power Administration (SEPA) markets the power (capacity and energy) from these projects on a system wide basis.	USACE analysis of hydropower impacts will consider both system-wide generation as well as project-specific generation for various water management and water supply alternatives.	Section 6.5.3; Appendix B
HP6	In the EIS, the USACE needs to honor the limitation suggested by a *slight decrease* that the Newman report envisioned when hydropower would diminish to allow for increased water supply. The term slight decrease has legal significance in determining how far the USACE should diminish maximum power production to accommodate increased water supply. Any modeling of a drop in hydropower production should be measured against the benchmark established by the use of the term slight decrease.	USACE will evaluate the hydropower impacts associated with various water management and water supply alternatives consistent with the 2012 Legal Analysis.	Section 4.1; Section 6.5.3; Appendix B
HP7	The USACE should use the methodology employed in the remand modeling to evaluate the impact of alternative rules and system operations on hydropower and to appropriately balance the substantial other benefits that may be achieved against the potentially small impacts on hydropower.	USACE will evaluate potential impacts to hydropower capacity and revenues associated with potential water management alternatives and various water supply storage volumes, as well as other aspects of hydropower generation, to ascertain the potential impact to hydropower production throughout the ACF system.	Section 4.1; Section 6.5.3; Appendix B
HP8	The data in the USACE Hydropower Analysis indicates that the variable cost of an alternative thermal generation resource to replace lost hydropower generation is significantly lower for Buford Dam than other hydropower stations on the ACF system; therefore, reducing the Buford Dam peak discharge levels, while maintaining the average daily power generation, should have a minimal effect on the power system.	Comment noted.	Section 6.5.3; Appendix B
HP9	The USACE should consider and provide for sufficient flows to maintain existing power generation at the GPC hydroelectric power plants on the Chattahoochee River and to plan for future generation of electricity to meet growing demand.	The USACE is aware of the GPC projects and their FERC minimum flow requirements, and the USACE will recognize them in the updated WCM and EIS. The USACE's minimum flow requirement from West Point Dam is 675 cfs, and the authorized purposes of the federal ACF system do not include operating the West Point project to ensure that the GPC complies with its FERC license.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
Flood Risk Management (FRM)			
FRM1	The USACE should not reduce the flood control capability of West Point Lake.	Each of the alternatives considered by the USACE would maintain at least the current level of flood risk management, as authorized by Congress. None of the alternatives would reduce flood storage capacity at West Point Lake.	Section 4.1.1
FRM2	USACE should maintain West Point Lake at 632.5 msl year round and managed to reduce flood risks.	Flood risk management (or flood control) is an expressly authorized purpose of the West Point Lake project and must be considered in making operational decisions. Raising the guide curve to 632.5 ft msl year round would reduce the flood storage capacity of West Point Lake and potentially increase flood risk downstream. Downstream encroachments heighten concerns that reducing flood storage capacity could pose threats to life and safety. USACE has limited the alternatives carried forward for full evaluation in the EIS to those that would not involve reductions in federal flood control capacity, or any other federal actions that are intended or expected to increase flood risk.	Section 4.1.1
FRM3	USACE is encouraged to review its flood management procedures to consider modifications to take advantage of technology and use real time USGS gauge data and imminent rainfall predictions to improve reservoir release response times.	In updating the WCM, USACE will include the most recent available data regarding basin conditions and best reliable forecasting services and technology.	Appendix A
FRM4	The USACE should manage West Point Lake for recreation, not flood control.	Flood risk management (or flood control) is an expressly authorized purpose of the West Point Lake project and must be considered in making operational decisions.	Section 4.1.1
FRM5	Raise Lake Lanier to 1,073 ft to use some of the excessive flood control storage in the lake.	USACE is considering some level of water supply out of Lake Lanier under the authority of the WSA as stated in the Notice of Intent issued October 12, 2012. USACE considered the concept of raising the top of conservation storage to 1073 ft msl (in effect, reallocating storage from the flood control pool to the conservation pool) in response to scoping comments. However, reallocation of the flood control pool for other purposes is not covered by the current effort. A Water Supply Storage Assessment is being prepared to address the water supply needs of communities currently withdrawing from Lake Lanier. Various alternatives to reallocation of storage from Lake Lanier to satisfy these needs will be considered.	Section 4.1.1

Number	Scoping Comment	USACE Response/Action	EIS Reference
FRM6	In view of developments in the ACF Basin, maximum channel capacity and revised flood stages need to be established for flood control.	Based on operational experience gained over the past decades, USACE has modified operations to reflect changes to channel capacities downstream of the ACF dams. Flood stages are established by the National Weather Service and outside the purview of the USACE.	Section 4.1.1

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Appendix E

HEC ResSim Modeling Report

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Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

June 2014

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PR-92B

Table of Contents:

List of Tables:

List of Figures:

List of Appendices

I. Introduction

This report describes the continuing reservoir system modeling performed in support of the Mobile District Water Control Manual (WCM) Update and Water Supply Storage Assessment (WSSA) Studies for the Apalachicola-Chattahoochee-Flint (ACF) River Basin (Figure 1). The main body of the report provides an overview of the model, the current conditions "NOAction" alternative, the measures studied for improving system performance, the iterative process for developing and evaluating alternatives, and the final "recommended plan" alternative. The appendices provide details of the modeling for each reservoir represented and of all the alternatives investigated.

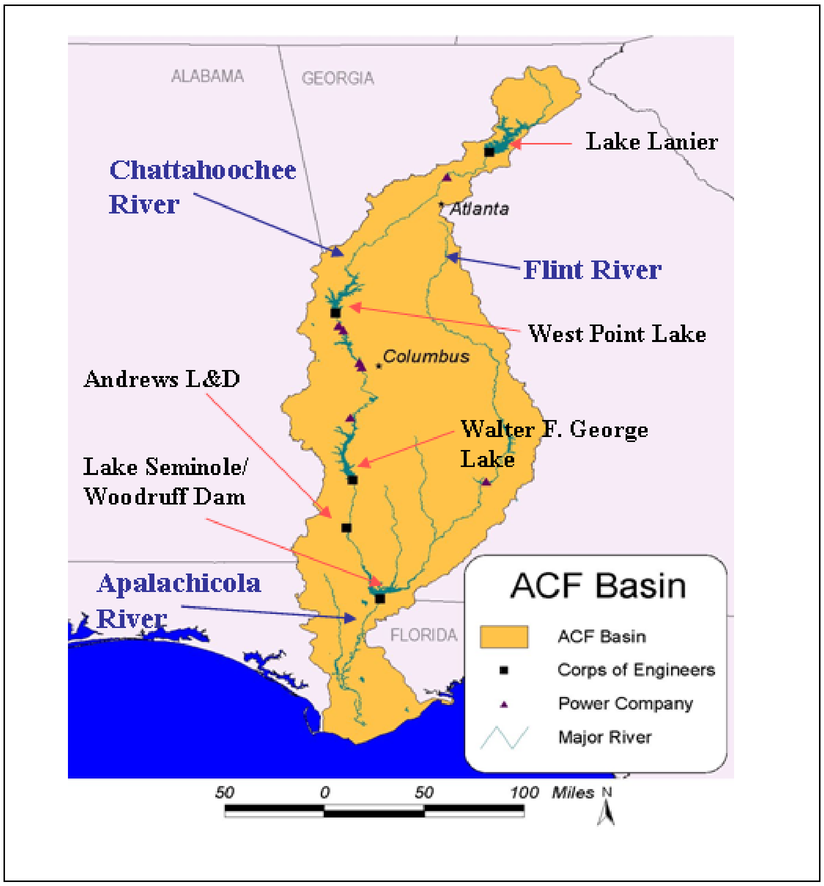

Figure 1. Apalachicola-Chattahoochee-Flint (ACF) River Basin

A. Overview of the ACF Reservoir System Model

The ACF reservoir system model was developed to simulate reservoir operations under a variety of operating schemes. The primary output of the reservoir system model consists of 73 years (1939-2011) of continuously simulated reservoir operations, lake levels and river flows throughout the ACF basin for both a NO-Action condition and an array of operational alternatives outlined by the ACF Project Delivery Team (PDT). PDT members reviewed these results in terms of socioeconomic, environmental, and operational impacts to verify that the model adequately reflected the interim operating plan that currently guides reservoir operations in the basin as well as the operational alternatives and water supply scenarios they wished to analyze. Once the PDT determined that each alternative was correctly operating the reservoir system as intended, comparison of the relative differences among the results of the model alternatives allowed the PDT to identify a set of operational goals and constraints that could most effectively guide reservoir operation in the basin while meeting all the projects' purposes. The final "recommended plan" incorporates this best set of operations for the reservoirs of the ACF basin.

The modeling team began work on the study model in 2008 and work continued through the Water Control Manual update Environmental Impact Statement (EIS) process. Early phases of the study resulted in the basis of the current operations model which reflects the 2012 Revised Interim Operation Plan (2012 RIOP, USACE 2012). The final phase of the study began in Jan 2013. Most of the *initial* effort of this phase was spent on two tasks:

- Validation of the model in HEC-ResSim 3.2. HEC-ResSim Version 3.1 was used for the early phases of the study.
- Refinements to the NO-Action model. In concept, the study required only relative differences in the results be used to compare alternatives, 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 NO-Action reservoir system model eventually grew to include all the detailed physical characteristics available and almost all the operational rules used at each project in the system.

Although the initial effort to establish a good "current condition" model was not inconsiderable, the plan formulation process accounted for the bulk of the study effort. Ground rules for the WCM Update study did not allow structure improvements or other physical changes to be considered thus limiting the alternatives to differences in how to operate the federal projects and the impacts due to a range of water supply demands on the system. The modeling team implemented and evaluated many individual changes to operations as proposed and defined by the PDT. These operational changes were referred to as "measures". The measures underwent iterative refinements, both separately and in conjunction with other measures. The recommended plan includes those measures that the PDT determined to be the most beneficial to the overall operation of the system.

B. The Reservoirs of the ACF Basin

The following information is excerpted from the Mobile District's web page regarding "Master Water Control Manual Update Environmental Impact Statement for the Apalachicola – Chattahoochee – Flint River Basin" (http://www.sam.usace.army.mil/Missions/PlanningEnvironmental/ACFMasterWaterControlManualUpdate.aspx):

> *The Corps Water Management Section of the Mobile District operates five federal reservoir projects: Buford Dam (Lake Lanier), West Point Dam, Walter F.*

George Lock and Dam, George W. Andrews Lock and Dam, and Jim Woodruff Lock and Dam (Lake Seminole) as components of the ACF system.

These are multi-purpose projects for which operations have been congressionally authorized either through the original project authorizations, or by subsequent congressional authorizations that apply generally to all Corps reservoir projects. The reservoir projects are operated in a balanced manner within the system to support all authorized project purposes within the ACF system to the extent practicable.

The Corps does not prioritize the project purposes but does use action zones that have been defined for each of the major storage reservoirs in the ACF system—Lake Lanier, West Point Lake, and Walter F. George Lake. These action zones, which are outlined in the 1989 Draft Master Water Control Manual (USACE, 1989), are used to determine minimum hydropower generation and maximum navigation releases from conservation storage in the lakes while balancing the lake levels in a system-wide approach.

The guidelines in the Water Control Manual reduce the amount of water available for augmenting navigation flows and other project purposes as drought conditions intensify in the basin. Ultimately, during times of drought, operations in support of navigation and hydropower may become very limited and recreation will be affected.

The strategy of operating the projects also calls for water to be taken first from storage in the lower lakes on the system and gradually pulling water from the upper lakes over time. Thus, Walter F. George, which contains most of the storage on the lower system because Lake Seminole does not have much storage, will be the first lake to be affected by operations on the system during periods of low water. If conditions remain dry, water will also be pulled from West Point Lake and eventually Lake Lanier. This is all done in accordance with the action zones and guidelines in the Water Control Manual, which attempts to equitably balance the lakes in the system. Varying hydrologic conditions throughout the ACF River Basin may result in the lakes getting out of balance; but, eventually, they will be brought back into balance according to the manual.

In addition, the model includes five projects owned and operated by the Georgia Power Company (GPC) and two proposed water supply projects. The GPC projects are Morgan Falls and Bartletts Ferry on the Upper Chattahoochee River, and Goat Rock, Oliver, and North Highlands on the Middle Chattahoochee River. The proposed projects are Glades Reservoir on Flat Creek upstream of Lake Lanier and Bear Creek Reservoir on Bear Creek upstream of West Point Reservoir. Since the No Action alternative must represent the current physical and operational state of the ACF system, it does not include Glades and Bear Creek reservoirs. However, because the likelihood that these projects will be constructed in the near future, the PDT included them in the operational alternatives studied.

C. Model Selection

This analysis used "HEC-ResSim Version 3.2, Build 3.2.1.19" (USACE, 2013). HEC-ResSim is a generalized reservoir operations modeling package.

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

The Water Control Manual Update team selected HEC-ResSim as the tool most capable of faithfully representing District water management practices as the culmination of a three-year model development and verification process. In 2006 Mobile District began working with HEC to create HEC-ResSim models based on established HEC-5 models simulating 1977, 1995, and 2006 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, the 1990's Comprehensive Study, and the Revised Interim Operating Plan (RIOP). 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, including the Revised Interim Operating Plan rules and head limits constraints. This model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF 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 program enhancements, 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 continuity.

The Mobile District's decision to use HEC-ResSim for modeling the ACF watershed represents a long term investment that continues to pay dividends. Completion of the ACF ResSim model for the initial water control manual update study in 2010 yielded a set of alternatives and associated results that passed the Corps' internal and external review processes. The model results continue to serve as a basis of debate among the stakeholders and provided the operational flows used in the water quality model for the EIS process. A spinoff of the NO-Action model was used to perform a basin-wide yield analysis requested by Congress. Mobile District modelers expanded the WCM model to reflect alternatives required during the "remand" process required by the Federal Appellate Court. And, the current operations alternative completed under the remand modeling became the basis of the NO-Action alternative for this phase of the study.

Figure 2 shows a general location map of the study area as represented by the ResSim model. The image is of the main window of the ResSim Watershed Setup module showing the base schematic of the ACF ResSim watershed model named "ACF_WCM-2014". Details of the watershed model will be presented in subsequent sections and appendices of this report.

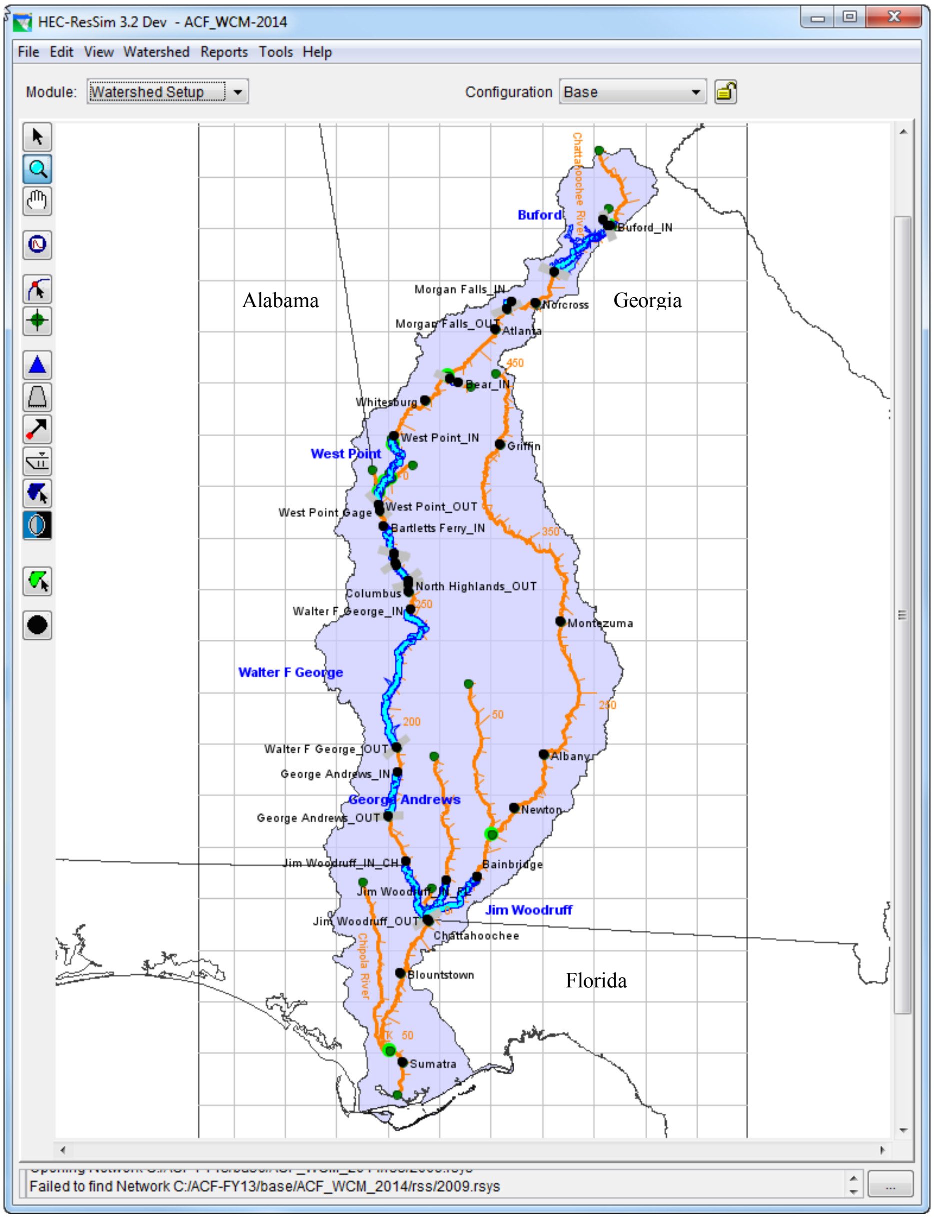

Figure 2. ACF Model – Watershed Setup Module

D. HEC-ResSim Improvements

HEC-ResSim 3.2 used for this phase of the WCM study. It has several improvements compared to HEC-ResSim 3.1 which was used in the initial phase. The two improvements included in ResSim 3.2 that prompted the move from 3.1 are the new Automated Firm Yield Analysis and the improved compute block logic (which reduced compute times substantially). Other advantages include improved handling of seasonal data during leap years, improved Carters pump-back operation, improved downstream control logic (especially with respect to rate of change rules and routing), improved evaporation and area calculations, updated zone boundary logic, and expanded scripting features for State Variables and Scripted Rules

II. Overview of the ACF System Model

This section describes the basic attributes of the ACF System model used to simulate the NO-Action condition and the (alternatives that resulted in the) recommended plan. The appendices contain more detailed information, including descriptions of differences between the NO-Action model, intermediate alternatives, and recommended plan.

As illustrated in Figure 3, the complete ACF watershed model extends from the headwaters of the Chattahoochee River above Lake Lanier and the headwaters of the Flint River above Griffin through the confluence of the two rivers at Lake Seminole and down the Apalachicola River to Sumatra. Operations in the model extend from the proposed Glades reservoir above Lake Lanier through Buford dam to the tailwater of the Jim Woodruff Lock and Dam Project (represented by the USGS Chattahoochee gage 02358000). The watershed schematic shown in Figure 3 includes the location of the reservoirs, junctions, and diversions represented in the ACF system model by the "2014" network (used for modeling the intermediate and recommended plan alternatives).

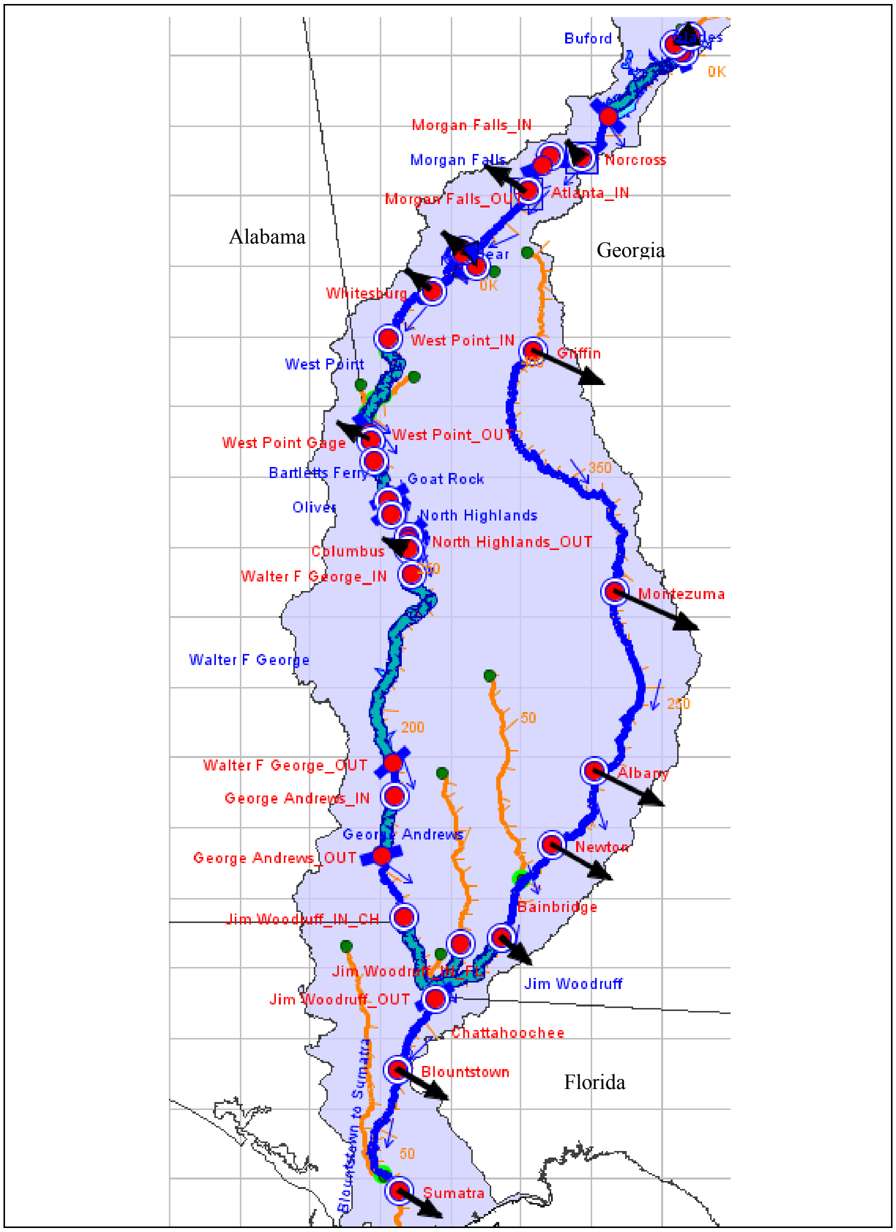

Figure 3. HEC-ResSim Network Schematic – "2014" Network

A. Reservoir Projects

The ACF Basin consists of two main tributaries: the Chattahoochee River and the Flint River, which join to form the Apalachicola River as previously shown in Figure 1. Principal flow regulation capabilities within the basin are restricted to the Chattahoochee River that is impounded by several dams located all along its length. The Flint River is essentially unregulated.

The Chattahoochee River reservoirs fall into two categories, Federal and Non-Federal projects. The Federal projects are operated by the US Army Corps of Engineers. The *existing* non-Federal projects are owned and operated by the Georgia Power Company.

The Federal Projects

The Corps operates five dams in the ACF River Basin, Buford, West Point, Walter F. George, George Andrews, and Jim Woodruff. All are located entirely on the Chattahoochee River arm of the basin except the downstream-most dam, Jim Woodruff, which is located immediately below the confluence of the Chattahoochee and Flint Rivers and marks the upstream extent of the Apalachicola River (see Figure 11). George Andrews is a lock and dam without any appreciable water storage behind it, but Buford, West Point, Walter F. George, and Jim Woodruff dams are impound reservoirs (Lakes Lanier, West Point, Eufaula, and Seminole, respectively) with a combined conservation storage capacity (relative to the top of each reservoirs' full summer pool) of about 1.6 million acre-feet (1,049,400 acre-feet at Lanier, 306,100 acre-feet at West Point, and 244,000 acre-feet at Walter F. George). Because Jim Woodruff Dam/Lake Seminole is operated as a run-of-river project, only very limited storage is available for support of project purposes.

The Federal projects in the ACF Basin are operated to provide for the following authorized purposes:

- flood control
- fish and wildlife
- navigation
- hydropower
- water supply
- water quality
- recreation

Each of these authorized project purposes is considered when making operational decisions which affect how water is stored and released from the projects.

In general, in order to meet the authorized project purposes, flow must be stored during wetter times and released from storage during drier periods. Traditionally this means that water is stored in the lakes during the spring, and released for authorized project purposes in the summer and fall months. In contrast, some authorized project purposes such as lakeside recreation, water supply, and lake fish spawn habitat are achieved by retaining water in the lakes, either throughout the year or during specified periods of each year. The flood control purpose at certain reservoirs require that the reservoirs be drawn down in the fall through winter months to provide temporary storage of possible flood waters and refilled in the spring months to provide water for other project purposes throughout the remainder of the year.

The conflicting water demands on these reservoirs require that the Corps operate them as a system in order to meet *all* authorized purposes, while continuously monitoring water availability to ensure that *minimum* project purposes can be achieved during critical drought periods. The balanced water management strategy for the Corps reservoirs in the ACF Basin does not prioritize any project function, but seeks to balance all authorized purposes. The intent is to maintain a balanced use of conservation storage among all the reservoirs in the system, rather than to maintain the pools at or above certain predetermined elevations.

The major stream regulation in the basin by the system of Federal projects is provided by Lake Sidney Lanier (modeled using the dam name Buford), located approximately 50 miles northeast of Atlanta, Georgia. This project provides 65% of the total conservation storage capacity available in the basin for flow regulation. It is important to note, however, that this project only controls runoff from 5.3 percent of the basin's total drainage area. Lesser, but significant, amounts of storage are also provided by two other Federal projects in the basin, West Point and Walter F. George reservoirs. The remaining Federal projects, George Andrews reservoir and Lake Seminole (modeled using the dam name Jim Woodruff), are essentially run-of-river projects which depend largely upon inflows controlled by upstream impoundments to meet downstream requirements.

Each of the Federal reservoirs is briefly described below, listed in order of position in the basin, from upstream to downstream. These reservoirs are described in detail in the Appendices A-G.

1. Buford

Lake Lanier (Buford) is a large federal reservoir with 1,087,600 AF of active storage, or about 65% of the total active storage in the ACF basin. It is difficult to refill Lake Lanier due to its small contributing area of only 1,040 square miles and the comparatively lower average annual rainfall this uppermost portion of the basin receives versus the rainfall over the rest of the Chattahoochee basin.

Water withdrawals take place both from Lake Lanier and from the Chattahoochee River downstream of Buford Dam to meet the water supply demands of metropolitan Atlanta (see Figure 4). Buford operations support water quality in the Chattahoochee by meeting a minimum flow of 750 cfs at the Peachtree Creek confluence. By releasing enough water from Buford to meet the required water quality flow objective at Peachtree Creek, the water supply withdrawals from the river are also met. This operation and other details about the ResSim modeling information of Buford are provided in Appendix A

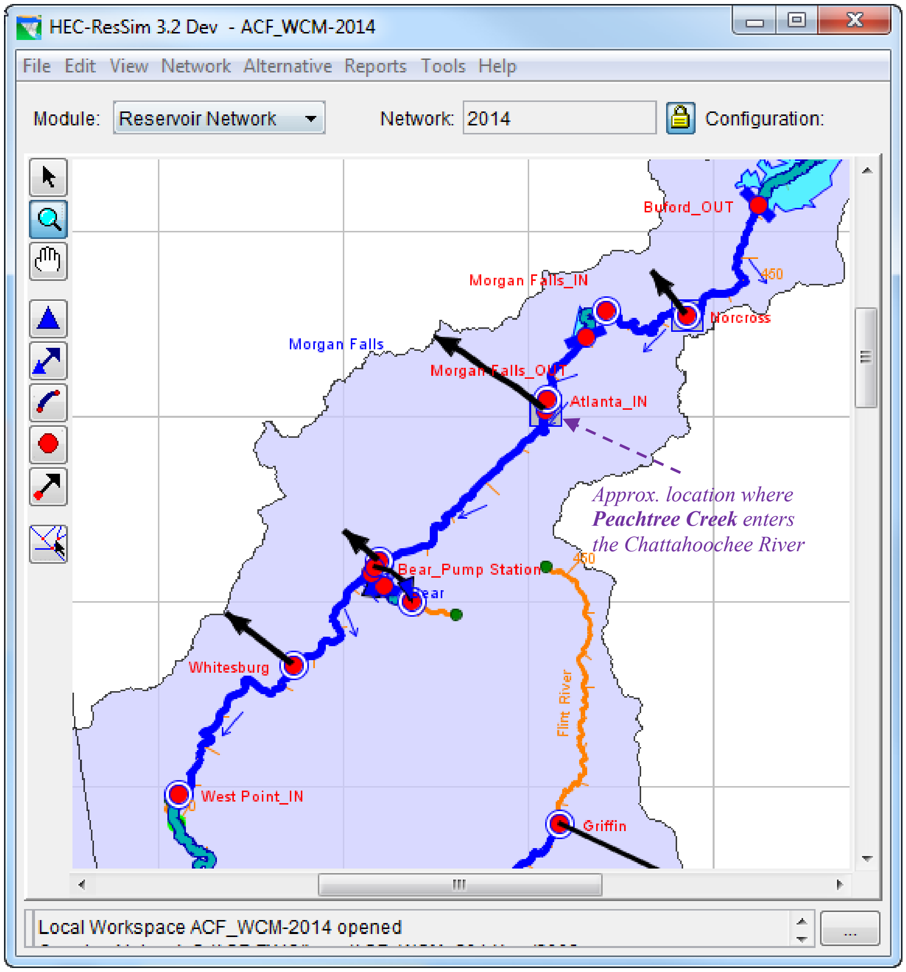

Figure 4. Chattahoochee River between Buford and West Point ("2014" Network)

2. West Point

West Point Dam is located on the Chattahoochee River at river mile 201.4, 3.2 miles north of West Point, Georgia. The West Point Dam is one of the critical components of the ACF system. The total drainage area above West Point Dam, 3440 square miles, represents about 40 percent of the contributing area of the Chattahoochee River basin. The local drainage area between Buford Dam and West Point Dam is about 2,400 square miles.

The powerhouse at West Point is normally operated as a peaking plant for the production of hydroelectric power. During off-peak periods, a small generating unit of the plant maintains a continuous flow of approximately 675 cfs. This flow is needed to maintain a reliable supply of high quality water to satisfy drinking water needs and sufficient assimilative capacity for wastes discharged into the Chattahoochee River below the dam (USACE, 1989).

In addition to hydropower production, another primary purpose of West Point Dam is flood control. The objective of the West Point flood control operation is to reduce flooding along the reach of the Chattahoochee River between West

Point Dam and Columbus, Georgia. Storage of 162,500 acre-feet between elevation 628 and elevation 635 has been reserved exclusively during the flood season for temporary storage of potentially damaging flood waters. This storage is available mid-December through February when the heaviest rainfall is expected to occur. Additional storage of 170,300 acre-feet above elevation 635 has also been reserved for flood storage and induced surcharge operation; this storage is reserved year-round. West Point's early spring refill period is timed to give the reservoir the best chance to refill in order to be ready to meet its demands through the late spring and summer months. Appendix B provides detailed ResSim modeling information for West Point.

3. Walter F. George

The Walter F. George Lock and Dam is located on the Chattahoochee River approximately 1 mile north of Fort Gaines, Georgia, and approximately 1.6 miles upstream from the Georgia State Highway 37 bridge. The total drainage area above Walter F. George Lock and Dam is 7,460 square miles. The project was designed, along with George Andrews and Jim Woodruff, to provide a 9-foot deep navigation channel that extends upstream to Columbus, Georgia. Flood control is another purpose for which the project provides benefits during peak flow periods.

The major operating constraint that must take precedent over all others is a structural head limitation; the difference between the headwater and tailwater must not exceed 88.0 feet. Downstream projects, George Andrews and Jim Woodruff also have structural head limits. Since each of these pools represents the upstream projects' tailwater, the headwater limitations constitutes a systematic constraint. Pool levels of the three Corps projects and flow to the Apalachicola River must be balanced so as not to exceed the structural head limits at any of the projects. Appendix C provides detailed ResSim modeling information for Walter F. George.

4. George Andrews

The George W. Andrews Lock and Dam is located on the Chattahoochee River at river mile 46.5, 2 miles south of Columbia, Alabama. The total drainage area above the dam is 8,210 square miles. George Andrews Lock and Dam was authorized as a single purpose project designed to aid navigation by providing a 9-foot navigation channel upstream to Walter F. George and by maintaining a reasonably uniform downstream flow. The plan of operation for Andrews Lock and Dam includes operations to support other objectives including re-regulating the erratic inflows caused by peaking power operations at the Walter F. George powerhouse, aiding in the production of hydroelectric energy by reducing the tailwater at Walter F. George prior to the commencement of generation, and providing for recreation and fish and wildlife conservation. Due to structural headlimit constraints, the George Andrews pool will not be drawn down below elevation 96 and will not be allowed to rise above elevation 103 during reregulation of peaking power releases. Since the George Andrews project's reregulation operations only fluctuate its pool over a period of less than a day, it is represented in the daily ResSim model as a "flow-through" project. Appendix D provides detailed ResSim modeling information for George Andrews.

5. Jim Woodruff

Jim Woodruff Lock and Dam is located about 1,000 feet downstream from the point where the Chattahoochee and Flint Rivers combine to form the Apalachicola River. It is about 3,200 feet upstream from the U. S. Highway 90 Bridge and 1.6 miles northwest of the town of Chattahoochee, Florida. The total drainage area above Jim Woodruff Dam, 17,230 square miles, is about equally divided between the Chattahoochee and Flint Rivers. Jim Woodruff is a multi-purpose project created primarily to aid navigation in the Apalachicola, Chattahoochee, and Flint Rivers and to generate electric power.

The reservoir level is normally maintained near elevation 77.0 with +/- one-half foot being used to re-regulate erratic flows into the reservoir from upstream hydroelectric peaking plants. Since there is no flood control storage available at the project, the reservoir level at the dam will be maintained at elevation 77.0 by passing the inflow through the power plant and then the spillway gates. When the full discharge capacity of the spillway is reached during periods of high flows, the overflow spillway will discharge the excess.

Like the Walter F. George and George Andrews projects, the Jim Woodruff Lock and Dam has a maximum head limit due to structural stability. In addition, the Jim Woodruff project observes a number of very significant and complex environmental requirements, including actions contained in the Revised Interim Operations Plan (RIOP) at Jim Woodruff Dam, Gulf Sturgeon Spawning Operational Consideration, and Fish Spawning Operational Consideration for Lake Seminole and the Apalachicola River. Appendix E provides detailed ResSim modeling information for Jim Woodruff.

The Non-Federal Projects

On the upper and middle Chattahoochee River, there are five projects that are owned and operated by Georgia Power Company (GPC). From upstream to downstream, they are Morgan Falls, Bartletts Ferry, Goat Rock, Oliver, and North Highlands. Because these projects do not have much storage, they are operated as run-of-river projects and modeled as pass-through (flow-thru) projects in the daily ResSim model. The primary reasons for including these projects within the ACF System model are to estimate evaporation losses due to the impoundments and to approximate hydropower generation for use as a metric for alternative comparison.

Although not part of the current condition (No Action) alternative, two proposed water supply reservoirs, Glades and Bear Creek, were added to the model to enable the PDT to analyze their potential impacts on the system operation. Glades Reservoir is located on Flat Creek upstream of Buford and Bear Creek Reservoir is located on Bear Creek upstream of West Point. These project have been proposed by the regional water districts which they are intended supply.

The non-Federal reservoirs of the ACF basin model are briefly described below, listed in order of position in the basin, from upstream to downstream. These reservoirs are described in detail in the Appendices F and G.

6. Glades

Hall County proposes to construct a dam on Flat Creek, a tributary of the Chattahoochee River, to create the Glades Reservoir. The primary purpose of the proposed reservoir is for long-term water supply for Hall County, Georgia. The dam is proposed to be an earthen embankment dam with a height of approximately 115 feet and a crest length of 1,000 feet. The top of dam elevation is estimated to be at 1,195 feet above mean sea level (ft MSL) and the normal pool water surface elevation is proposed to be at 1,180 ft MSL. Hall County estimates that 20% of the total storage will be reserved for sediment storage. The outlet works will consist of a controlled outlet for release to Flat Creek below the dam and an overflow spillway. The proposed dam is intended to pass the annual 7-day, 10-year minimum flow (7Q10) of Flat Creek, estimated at 4.6 cubic feet per second (cfs) or the natural inflow, whichever is less. When the proposed Glades Reservoir reaches capacity at the normal pool water surface elevation of 1,180 ft MSL, all additional volume will be passed through the spillway. Appendix G provides detailed ResSim modeling information for Glades.

7. Morgan Falls

The GPC Morgan Falls Project is located at river mile 312.6 near Roswell, Georgia. The project was constructed between 1903 and 1904. Morgan Falls Dam creates a narrow 673-acre impoundment called Bull Sluice Lake. Georgia Power currently operates the Morgan Falls Project in a modified run-of-river mode for the primary purposes of power generation, domestic water supply, and wastewater assimilation for metropolitan Atlanta. Over the course of each day, Georgia Power uses the reservoir's very limited operating storage to the maximum extent possible to re-regulate peaking power releases from Buford Dam. However, due to the daily time step of the model and the very small storage capacity of the impoundment, the ResSim model represents Morgan Falls' as a "flow-thru" project. Appendix F provides detailed ResSim modeling information for Morgan Falls.

8. Bear Creek

Bear Creek reservoir is a proposed water supply reservoir. Its dam site, located on Bear Creek approximately 2400 ft upstream of its confluence with Chattahoochee River, was selected by the South Fulton Municipal Regional Water and Sewer Authority to impound a 440 acre reservoir intended to meet the future water supply needs of the cities of Fairborn, Palmetto and Union City located in the southern portion of Fulton County. Appendix G provides detailed HEC-ResSim modeling information for Bear Creek.

9. Bartletts Ferry

The GPC Bartletts Ferry project is located approximately 23 miles downstream of West Point Dam. It is a medium to small sized reservoir with limited operating storage. Only 18% of flows entering the Bartletts Ferry project come from local drainage; the rest is controlled by West Point Dam. The reservoir is currently operated at near full pool year-round with normal daily average fluctuations of about ¾ foot. Since the project effectively passes inflow on a daily basis, it is represented in the daily ResSim model as a “flow-thru” project. Appendix F provides detailed ResSim modeling information for Bartlett’s Ferry.

10. Goat Rock, Oliver, and North Highlands

The GPC Middle Chattahoochee Project consists of (from upstream to downstream): Goat Rock Dam, Oliver Dam, and North Highlands Dam. The total drainage area upstream of North Highlands Dam is 4,670 square miles. The local drainage area between West Point Dam and North Highlands Dam is 1,230 square miles. Nearly ¼ of the inflow into GPC’s Middle Chattahoochee Project is from local inflow between West Point and North Highlands. All three reservoirs have very limited storage. Georgia Power operates the Middle Chattahoochee Project in a run-of-river with pondage mode. The three reservoirs are represented in the ResSim model as “flow-thru” projects. Appendix F provides detailed ResSim modeling information for Goat Rock, Oliver and North Highlands.

B. Diversions

Water withdrawals occur in the ACF basin for various purposes. Water is diverted from the Federal and GPC projects as well as from the rivers. Withdrawals from the reservoirs are modeled differently than withdrawals from the rivers. The two withdrawal methods are:

1. Withdrawals from a reservoir are specified at the reservoir’s inflow junction as a *negative* local inflow, this method ensures that a withdrawal from a reservoir will never be “shorted”. Local inflows are mapped to HEC-DSS time-series records which hold the data representing the flow entering (or, when negative, leaving) the system at the junction.

2. Withdrawals from a river are modeled using ResSim diversion elements. These withdrawals might be constant, specified as an external time-series, or represented as a function of a model or scripted state 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 withdrawals, 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. Even if the pool is below inactive and unable to release water into the river, withdrawals will still take place until the pool is dry. This scenario represents the actual withdrawal conditions occurring in all the COE and GPC projects. For method 2, if there is insufficient inflow from upstream to meet the diversion amount, withdrawals will be shorted. This scenario represents the actual withdrawals from the river reaches. Figure 5 shows examples of both methods being used in the modeling of reservoir and river diversions.

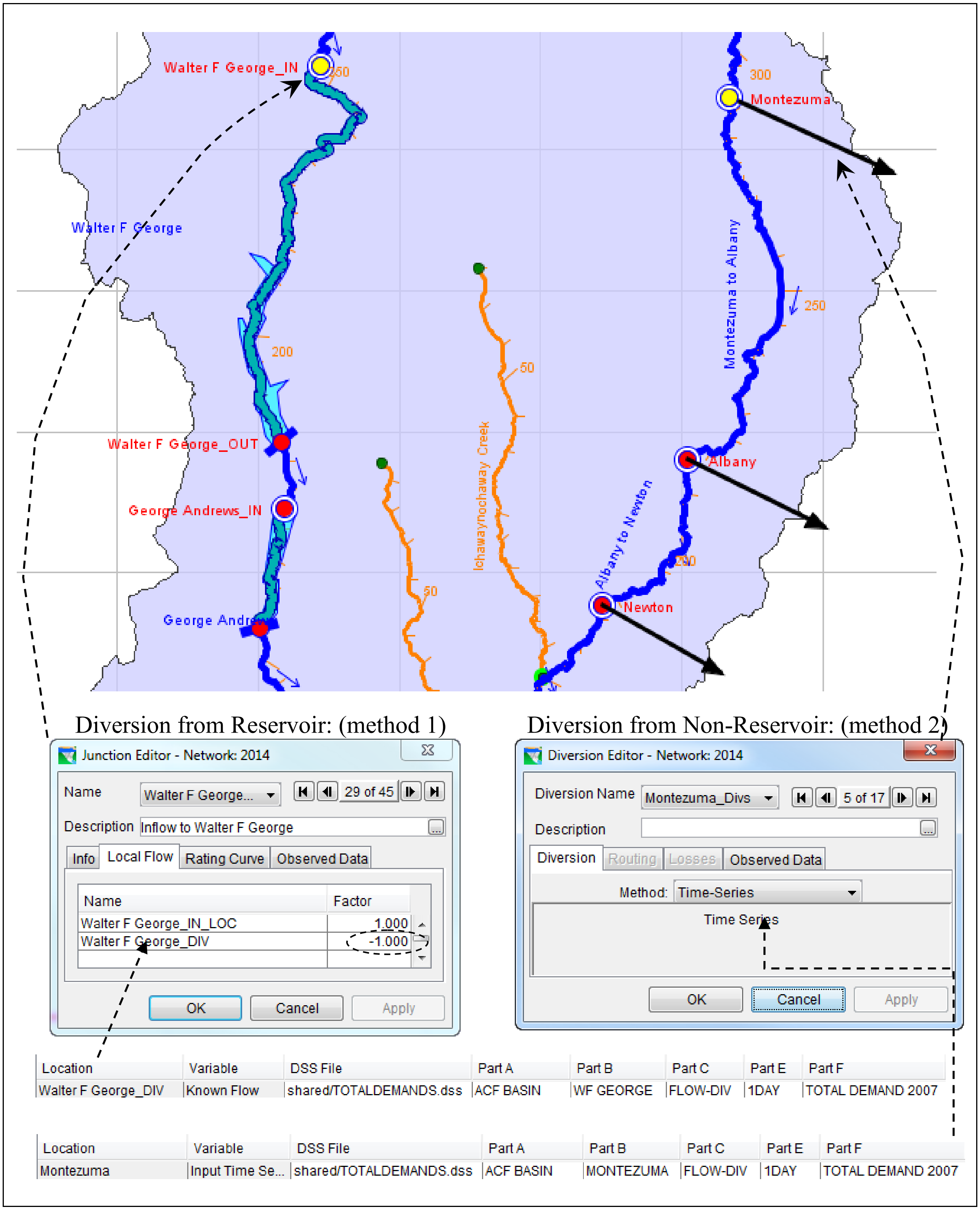

Figure 5. Two Methods Used in Modeling Diversions (for Reservoirs and Non-Reservoirs)

C. Routing

The HEC-ResSim software provides a set of hydrologic routing methods to be used by the modeler to represent the lag and attenuation affects on flow in a natural river system. The Muskingum routing method, which provides an easy means of representing both lag and attenuation, was selected for use in the final model because well-calibrated coefficients were available from an HEC-HMS (USACE, 2010b) model of the ACF basin and these Muskingum parameters were used in developing the unimpaired inflow data set.

ResSim's downstream operation logic attempts to account for the routing effects when one or more reservoirs are set to operate for a downstream requirement. ResSim's tandem balancing operation however, currently lacks the sophistication to 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.

Table 1 lists the routing parameters used in each reach. *(Note: in the Buford to Norcross reach, the routing parameters were modified to minimize negative impacts on the daily operation for downstream minimum flow requirements at Atlanta that were being caused by the tandem operation and its difficulty in accounting for the routing effects in the reaches above the control point. The parameters used are shown in parentheses in Table 1.)*

Table 1. Routing Parameters Used in the ACF Watershed

River	Reach	Length (mi)	Muskingum K (hrs)	Muskingum X	Steps
Flint	Griffin to Montezuma	124	120	0	5
Flint	Montezuma to Albany	77	48	0	2
Flint	Albany to Newton	34	24	0	1
Flint	Newton to Bainbridge	40	24	0	1
Flint	Bainbridge to Jim Woodruff	29	No Routing Used		
Flat	Glades to Buford	0	No Routing Used		
Chattahoochee	PumpStation to Buford	2	No Routing Used		
Chattahoochee	Buford to Norcross	18	15 *(24)*	0.20 *(0.50)*	1
Chattahoochee	Norcross to Morgan Falls	18	No Routing Used		
Chattahoochee	Morgan Falls to Atlanta_IN	10	No Routing Used		
Chattahoochee	Atlanta_IN to Atlanta	0	No Routing Used		
Chattahoochee	Atlanta to US Bear Creek	42	24	0.2	1
Chattahoochee	US Bear Creek to Bear Creek_Pump Station	0	No Routing Used		
Chattahoochee	Bear Creek_Pump Station to Bear Creek-Chattahoochee	1	No Routing Used		
Chattahoochee	Bear Creek-Chattahoochee to Whitesburg	15	No Routing Used		
Chattahoochee	Whitesburg to West Point R	61	24	0.50	1
Chattahoochee	West Point R to West Point G	2	No Routing Used		
Chattahoochee	West Point G to Bartletts Ferry	21	No Routing Used		
Chattahoochee	Bartletts Ferry to Goat Rock	5	No Routing Used		
Chattahoochee	Goat Rock to Oliver	9	No Routing Used		
Chattahoochee	Oliver to North Highlands	1	No Routing Used		
Chattahoochee	North Highlands to Columbus	3	No Routing Used		
Chattahoochee	Columbus to W.F. George	85	24	0.30	1
Chattahoochee	W.F. George to George Andrews	29	No Routing Used		
Chattahoochee	George Andrews to Jim Woodruff	47	18	0.25	1
Bear Creek	Bear Creek to Bear Creek-Chattahoochee	1	No Routing Used		
Apalachicola	Jim Woodruff to Chattahoochee	1	No Routing Used		
Apalachicola	Chattahoochee to Blountstown	29	18	0	1
Apalachicola	Blountstown to Sumatra	58	90	0.15	4

D. Boundary Conditions

The 73-year period of record that was simulated with HEC-ResSim spans calendar years 1939-2011. The unimpaired incremental local flows, evaporation, and diversion data were obtained from Mobile District. The developments of these data sets are described in unimpaired flow reports (USACE, 2014). Use of the unimpaired inflows allows the simulations to capture the natural variability of water supplies to the system in terms of flow frequency and volume.

E. Simulation Time-Step

The ACF 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 and HEC-ResSim modeling activities in the basin and maintains a degree of familiarity for partners and stakeholders. In addition, some boundary condition data (i.e., diversion amounts and unimpaired inflows) are only available as daily or monthly values, and offer no advantage from a finer time interval. Time constraints precluded development and vetting of sub-daily boundary condition data for period-of-record analysis. Finally, for such a complex study (many alternatives, complicated operations, and long simulation period), a daily time step makes it feasible to compute all alternatives in an efficient and timely manner.

The daily time-step provides adequate granularity to capture the effects of conservation operations, provided that hydropower generating rules and certain flood control operations are formulated properly for the interval. A sub-daily interval allows refinement of hydropower generation and flood control rules. A special hourly sub-model focusing on the West Point reservoir response to various synthetic flood hydrographs informed the evaluation of measures regarding the District's flood control authority. This topic is covered in Section II.G of this report. Additionally, the Mobile District has developed a second hourly model, as part of a separate real-time water management project (USACE, 2011).

F. System Operations

The four large federal reservoirs in the ACF watershed, Buford, West Point, Walter F. George, and Jim Woodruff, are viewed as a system 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 including local project and system requirements, time-of-year, weather conditions and trends, downstream needs, and the amount of water remaining in storage.

In addition to water supply and hydropower, one of the significant demands on the ACF system is to provide minimum flows in the Apalachicola River to support the habitat of several threatened and endangered species native to the region. These Endangered Species Act (EPA, 1969[2000]) releases are assigned to Jim Woodruff but are supported by the upstream reservoirs through tandem balancing operations. To provide system-wide balance in using conservation storage to meet this and other system requirements, a number of action (storage) zones were developed for the four principal Corps reservoirs, Buford, West Point, Walter F. George, and Jim Woodruff.

Action Zones

The 1989 draft ACF Water Control Plan specified the action zones for the three major storage projects on the ACF River Basin –Buford, West Point, and Walter F. George. These zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline as a result of drier-than-normal or drought conditions, Zones 2 through 4 define increasingly critical system water shortages and guide the Corps in reducing ESA releases from Jim Woodruff. The action zones also provide guidance on meeting minimum hydropower needs at each project and they determine the amount of storage available for downstream purposes such as flood control, hydropower, navigation, water supply, water quality, and recreation.

At the time of development, these zones were derived based on the past operation of the projects, which considered time-of-year, historical pool level/release relationships, operational limits for conservation, and recreational impact levels. The action zones are basic guidelines for balancing the storage in the system of reservoirs; however, local factors and activities might cause the lakes to operate differently than system balance may call for. These factors include flood control actions, fish spawn operations, maintenance and repair of turbines or gates, emergency situations such a chemical spill, draw-downs due to shoreline maintenance, releases made to free stuck barges, and other circumstances.

As much a possible, the three storage projects are operated to maintain their lake levels in the same action zones concurrently. However, because of the hydrologic and physical characteristics of the river system and the factors mentioned above, there might be periods when one lake is in a higher or lower zone than another. When this occurs, the Corps makes an effort to bring the lakes back into balance with each other as soon as conditions allow. By doing this, impacts on the river basin are shared equitably among the projects. The following definitions apply to the action zones:

- Zone 1: Indicates that releases can be made in support of seasonal navigation (when the channel has been adequately maintained), hydropower releases, water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that water to support seasonal navigation might be limited. Hydropower generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 3: Indicates that water to support seasonal navigation might be significantly limited. Hydropower generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 4: Indicates that navigation is not supported. Hydropower demands will be met at minimum level and might occur only for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

The action zones have provided a key management tool for more than 20 years. They play a substantial role in several aspects of operating the lakes and dams.

Figure 6 illustrates the water control action zones for Buford (Lake Lanier), West Point, and Walter F. George.

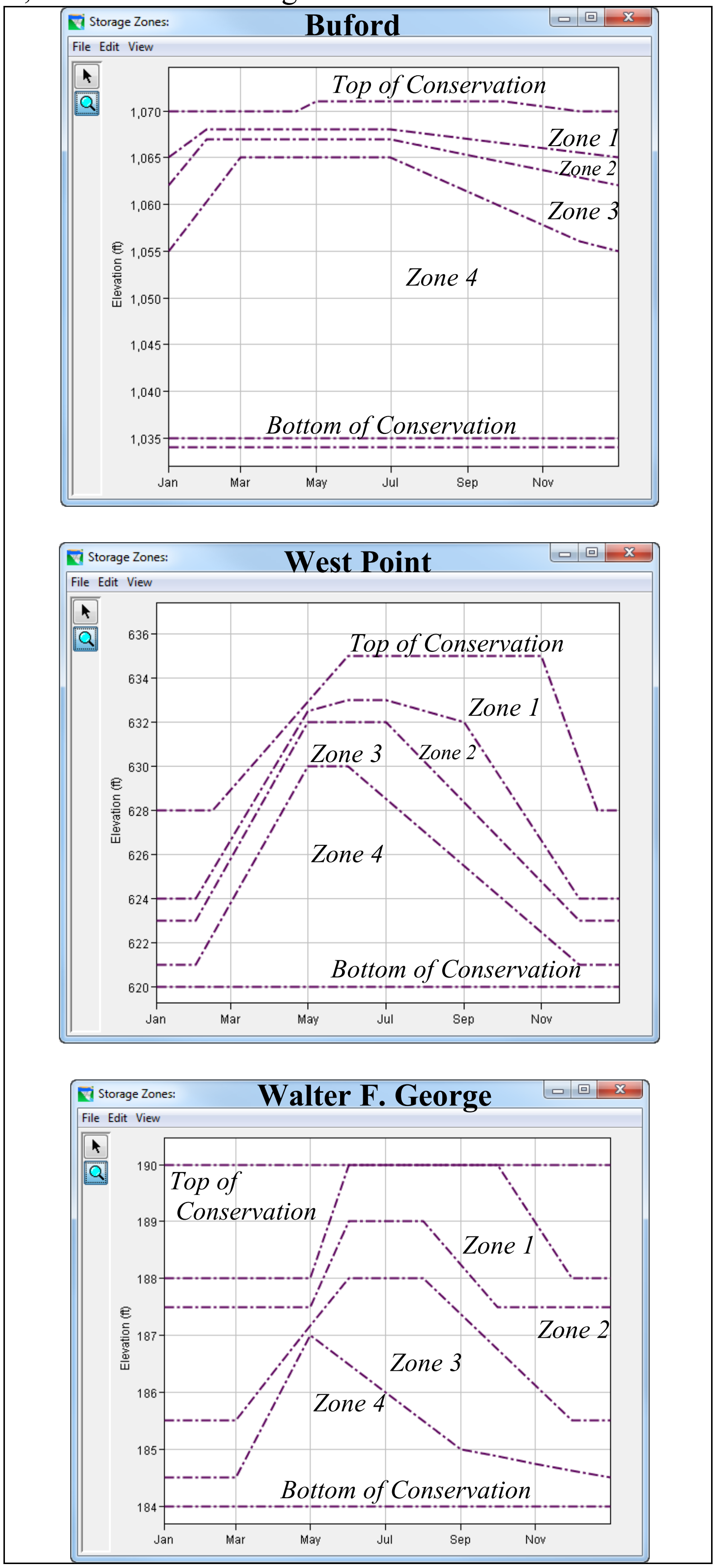

Figure 6. Water Control *Action Zones* for Buford (Lanier), West Point, and Walter F. George

In addition to specifying the local operation objectives, the storage of each Action Zone from each reservoir are summed to determine the composite system Action Zone storage and the current storage at each reservoir is summed to determine the composite system storage. This composite storage is then compared to the composite Action Zones to determine which Action Zone the *system* is in. The current system Action Zone is incorporated in the RIOP together with basin inflow and the current season to determine the minimum releases from Jim Woodruff Dam.

Tandem rules are used in Buford, West Point, and Walter F George to force them to support the minimum flow releases at Jim Woodruff by balancing their conservation storage within their Actions Zones with similarly defined Action Zones at Jim Woodruff. This balance is accomplished in the ResSim model through the specification of an explicit ‘zone by zone’ storage balance definition encompassing the four Corps projects. Figure 7 shows the Reservoir System editor and the explicit System Storage Balance named “EvenBalance_byZone_Noaction” (which is used by the NOAction alternative).

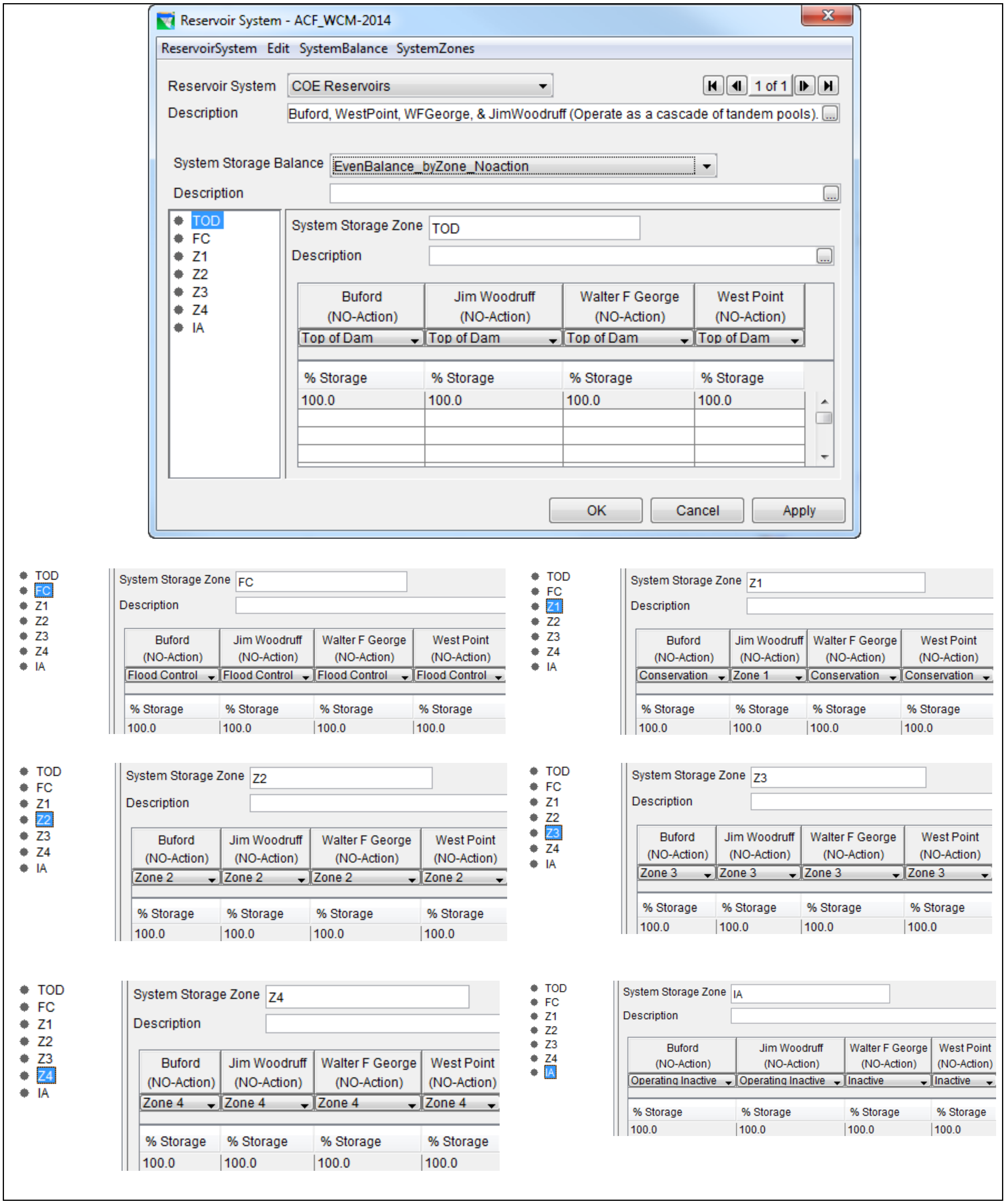

Figure 7. Reservoir System Balancing for NO-Action Operations:
Reservoir System = "COE Reservoirs";
System Storage Balance: "EvenBalance_byZone_NOAction"

G. Flood Modeling

An hourly flood study model (see Figure 8) from West Point Lake to Columbus, Georgia, was developed to evaluate any downstream flooding impact from proposed modifications to flood operations at West Point Dam. Synthetic unregulated frequency hydrographs were developed and used to run the flood model to obtain monthly regulated frequency hydrographs at Columbus. The combined regulated frequency curves at Columbus for the NO-Action and alternative conditions were generated and compared to evaluate the flooding impact from the modified flood operations at West Point Dam. For details of the flood modeling and results, refer to Appendix I.

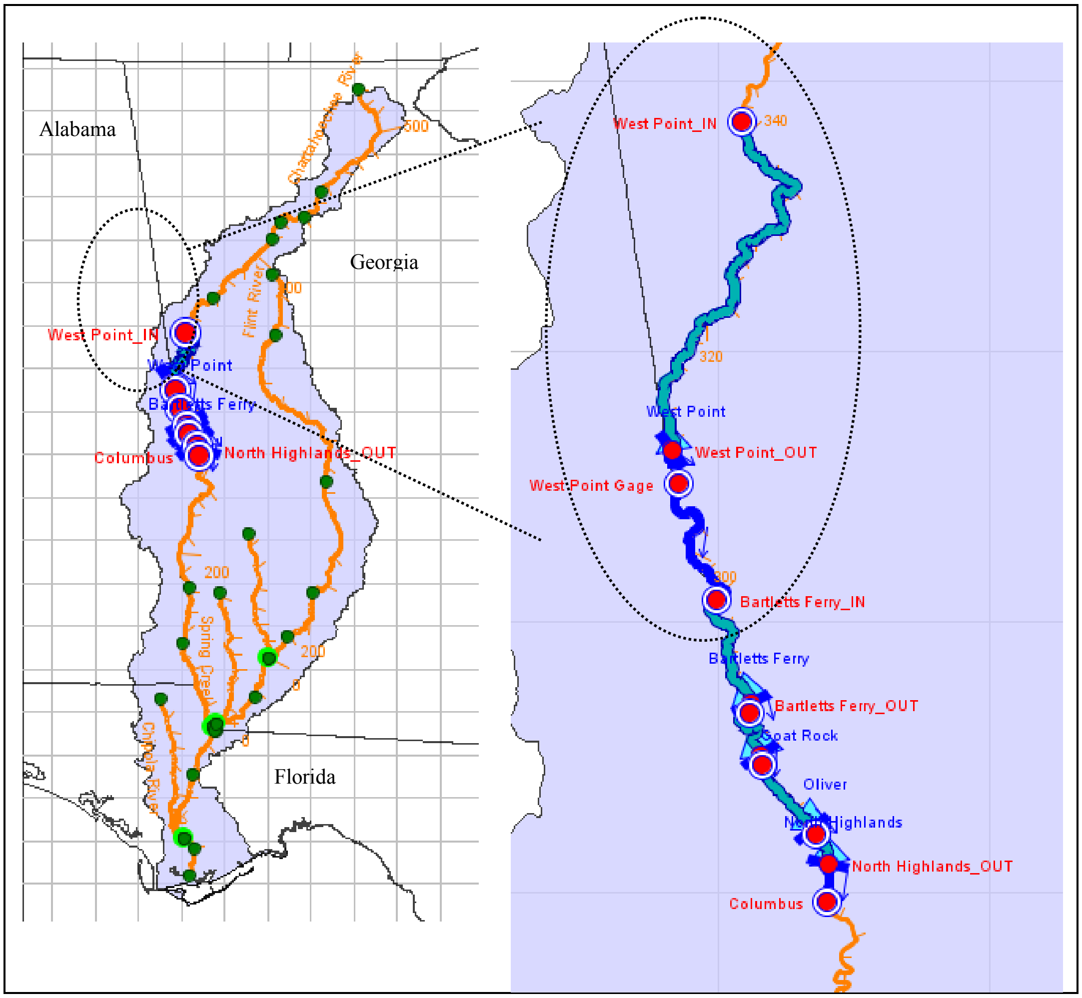

Figure 8. ResSim Network for ACF Flood Modeling (West Point to Columbus)

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 Columbus. The April 1990 and May 2003 events were selected to develop hourly unimpaired hydrographs, which were used to develop and calibrate an HEC-HMS model (Figure 9). The April 1990 and May 2003 unimpaired hourly hydrographs were scaled in an iterative manner and routed in the HEC-HMS model such that the hydrographs at Columbus 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.

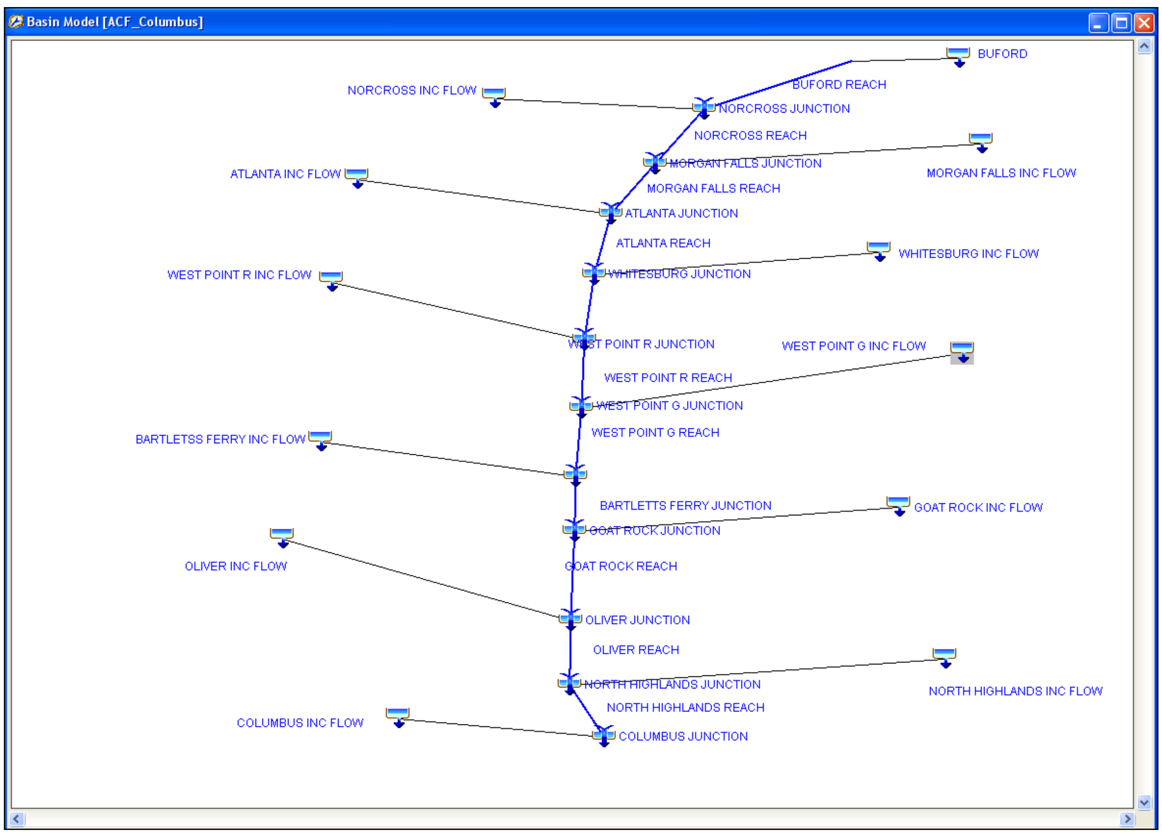

Figure 9. HEC-HMS Schematic for Generating Flood Hydrographs

Another analysis verified that the unregulated flow for a given event at West Point closely resembled that at Columbus, which justified centering the storm above the reservoir.

The volumes for each frequency event determined according to this procedure were distributed throughout the storm duration according to observed events in April 1990 and May 2003, resulting in a series of similarly shaped but differently scaled inflow hydrographs similar to those shown in Figure 10. The final step time-shifted each series of hydrographs to the 12 months of the calendar, allowing simulation of storms centered during different seasons and amounts of available flood control space.

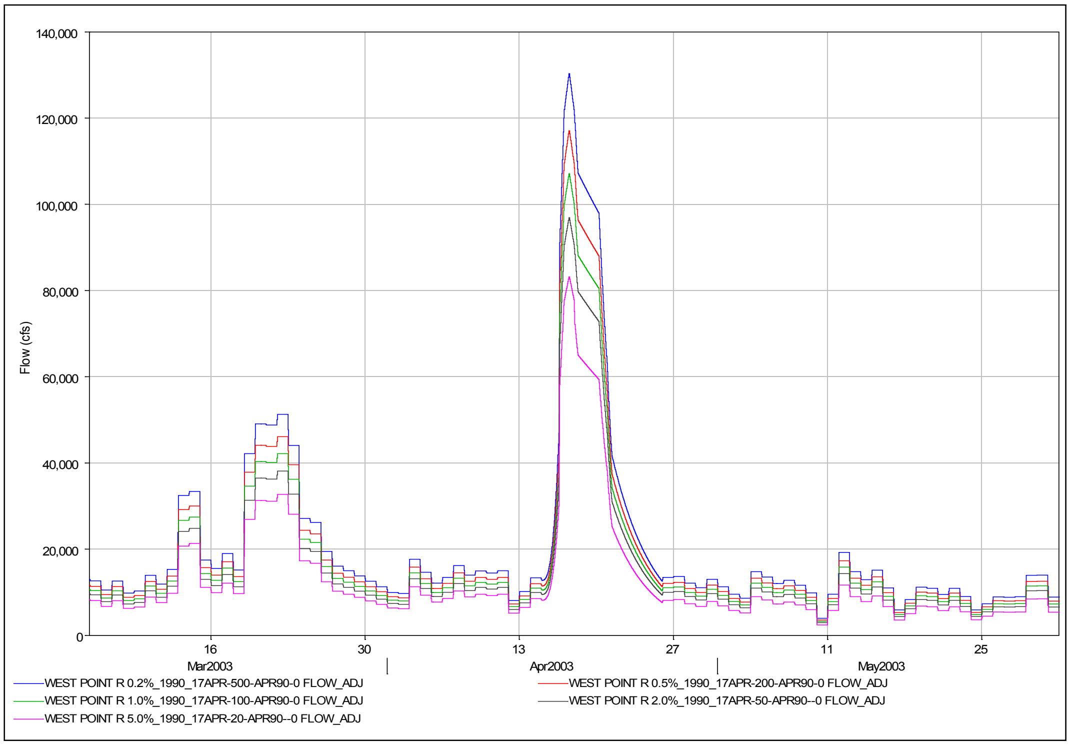

Figure 10. Synthetic Unimpaired Hourly Hydrographs at West Point Based on April 1990 Event

Appendix J 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 between West Point and Columbus, and was extracted from the master daily model. In addition to the different extents, a few physical and operational differences were made:

- Diversions were neglected, as they were determined to be too small to affect flood modeling.
- The outlets in the flood model provide greater detail regarding capacity according to ratchet gate openings. The ratchet opening detail was left out of the daily model as unnecessary complexity.
- In keeping with the model extents, the flood model does not include the reservoir system balance definition and rules related to other reservoirs (i.e., W. F. George tandem rule and Check_GC_Buffer logic).
- Power generation and fall rate rules in the flood control zone of the daily model were moved to a new zone in the flood control model named "Lower Flood Control". This arrangement improved calibration by allowing more flexibility where the pool might technically be in the flood control zone but operations reflect a more conservation-oriented mindset.
- The flood model carries additional details regarding induced surcharge operations, using separate definitions for winter or summer instead of a single rule.
- 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 ACF 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 Chattahoochee River 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 junction on the reach between Buford and West Point. Between West Point and Columbus, flows were apportioned to each ResSim junction in the flood model using the drainage-area-ratio method, based on observed flows at the USGS gages at New River and Upatoi.

The verification effort confirmed that the model's representation of the District's water management operations is correct. Evaluation focused on two differences between observed and modeled results:

1) The modeled peak reservoir elevation fell short of the highest observed pool level by approximately the amount of encroachment into the flood pool allowed by the water managers at the beginning of the event. The model is not intended to represent such discretionary judgments, so the

resulting peak pool level was considered a good verification. Figure 11 shows the verification of the September 2009 event at West Point.

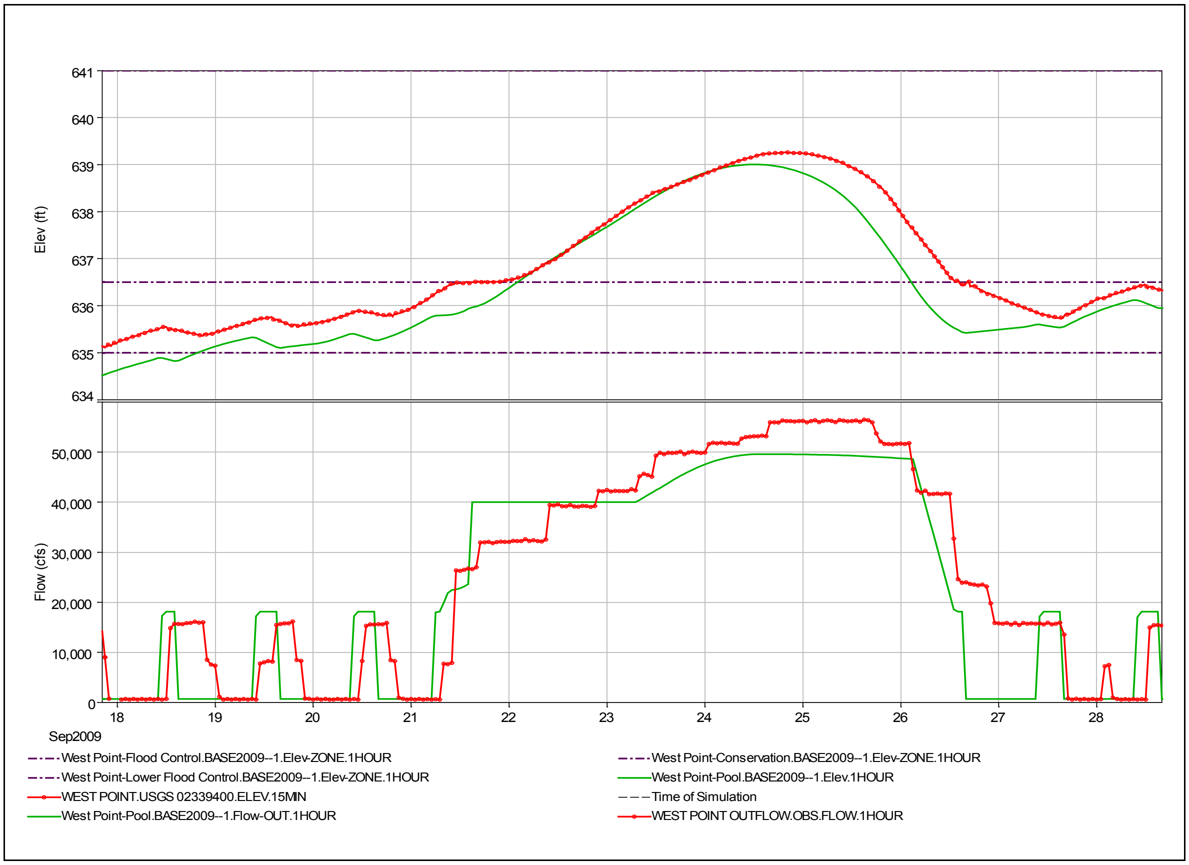

Figure 11. HEC-ResSim Results for September 2009 Event

2) The falling limb of the hydrographs below the GPC projects declined more gradually in the model than the observed flows, since the failure of flashboards at the GPC projects proved difficult to represent in ResSim. The ResSim team and Georgia Power Company worked diligently to represent the operations involving flashboards at the GPC projects between West Point and Columbus, but ultimately abandoned efforts to model flashboard failure, since only peak levels and flows from the flood model were needed. Sensitivity analyses showed that the flashboards fail very early in the event and get reset after the peak flows have passed, and have very little effect on the results at Columbus. Consequently, for the purposes of the water control manual update study the flood model neglected the failure and restoration, and represented the GPC project ratings without flashboards. The flashboard modeling work remains relevant to other District missions and carried into the CWMS (USACE, 2010c) models.

4. Evaluation of Results

The flood frequency flow at Columbus depends on the storm inflow hydrographs and the month for 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 Columbus by considering the exceedance probabilities of flood events occurring in different months. This was developed for both the NOAction and alternative conditions. The combined regulated flood frequency curves for the NOAction and alternative conditions were compared to evaluate any impact on downstream flood conditions from the modifications to the flood operations at West Point Dam. Appendix I describes the calculation procedure and presents the results in detail.

III. Description of NO-Action Operations

The ACF 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 ACF system. This requires comparison of anticipated effects due to a proposed new plan against those of the NO-Action condition.

Based on the nature of the proposed action (adopting a new set of water management guidelines), the NO-Action alternative represents continuation of the current water control operations at each of the Federal projects in the ACF system. The current operations are a set of project operations and water management policies and priorities in place since May 2012.

The Corps' operations have changed incrementally since completion of the 1958 ACF Master Manual. These changes were documented in a draft water control plan in 1989. However, additional incremental changes in water control operations have occurred since 1989, and are reflected in the current operations and the Revised Interim Operations Plan (RIOP) for Jim Woodruff. The NO-Action operations reflect operational practices on the ACF system as described in the following documents:

- Draft ACF Water Control Plan dated 1989 (USACE, 1989);
- Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA, February 1991 (USACE, 1991);
- Project Water Control Manuals for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.
- Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan, SAM SOP 1130-2-9, February 2005 (USACE, 2005);
- Revised Interim Operations Plan and Environmental Assessment, June 2008 (USACE, 2008);
- ACF ResSim Modeling in Support of WCM Update-Baseline, August 2010a.
- Revised Interim Operations Plan and Environmental Assessment, May 2012 (USACE, 2012);

In addition to the mentioned documents, below ones are used for the rest of the alternatives:

- Glades 404 permit, June 2011
- Bear Creek 404 permit, July 2011

The following subsections describe key operational elements that apply to the NO-Action operations.

Under the NO Action Alternative, the action zones specified in the 1989 Draft WCM and described in section F above are assumed to remain in effect. In addition, the Mobile District team developed an associated set of action zones for Lake Seminole. Although Lake Seminole does not provide significant storage for meeting the ACF system objectives, these zones at Lake Seminole were needed by the ResSim model to drive the tandem balancing operation of Buford, West Point and Walter F George in support of the ESA flow requirements.

A. Operations for Authorized Project Purposes

The following subsections describe each of the operations for the authorized project purposes in more detail:

1. Flood Control

The objective of flood damage reduction (flood control) operations on the ACF system is to store excess flows in an effort to keep downstream river levels below flood stage and/or produce no higher stages than those that would occur naturally. Whenever flood conditions occur, operation for flood control takes precedence over all other project functions. Of the five (5) Corps reservoirs, only the Buford (Lake Lanier) and West Point projects were designed with space to store flood water. In addition to providing space above the conservation pool to hold flood water throughout the year, the Buford project is drawn down one (1) additional foot, and the West Point project is drawn down at least seven (7) additional feet in the Fall to provide additional capacity through the winter and the early Spring to protect life and property within the basin. The George W. Andrews and Jim Woodruff Dams operate to pass inflows, while Walter F. George operates according to specified flood control schedules.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydropower demands are lower, increased flood control storage is made available in the model by specification of a seasonally varying guide curve (the Top of Conservation zone). Additional storage for containing flood waters is gained by drawing down the pool in late fall. During the principal flood season, December through April, the regulation plan at Walter F. George provides for lower lake levels to ensure lower reduced peak stages in the reservoir during major floods.

The timing of flood peaks in the ACF system is of considerable importance in determining the effectiveness of reservoir flood damage reduction operations and the degree to which such operations may be coordinated. During a flood event, excess water above normal pool elevation or "guide curve" should be evacuated through the use of the turbines and spillways in a manner consistent with other project needs as soon as downstream flows have receded sufficiently so that releases from the reservoirs do not cause flows to exceed the bankfull discharges. This timely evacuation is necessary so that consecutive flood events will not cause flood waters to exceed allocated flood storage capacities and endanger the integrity of the dam.

Flood control is represented in NOAction alternative using maximum release and downstream control rules at Buford and with maximum release rules at West Point and Walter F George.

2. Operations for Threatened and Endangered Species

The operation to support fish and wildlife habitat in the ACF Basin are influenced by three objectives: fish spawning, fish passage, and minimum flows.

a) Fish Spawning

The Corps operates the system to provide favorable conditions for annual fish spawning, both in the reservoirs and in the Apalachicola River. In most water years (1 October – 30 September) it is not possible to hold both lake levels and river stages at a steady or rising level for the entire spawning period, especially when the spawning periods overlap for the upstream lakes and/or the Apalachicola River. Therefore, for approximately 4 to 6 weeks during the fish spawning period for each specific water body, the goal of the Corps is to operate for a generally stable or rising lake level and a generally stable or gradually declining river stage on the Apalachicola River. When climatic conditions preclude a favorable operation for fish spawn, the Corps consults with the State fishery agencies and the USFWS on balancing needs within the system and minimizing the impacts of fluctuating lake or river levels. These fish spawn operations were incorporated into a draft Mobile District Standard Operating Procedure (CESAM SOP 1130-2-9) in February 2005, following consultation since 2002 with USFWS and state fishery management agencies from Alabama, Florida and Georgia. Under the NOAction Alternative, the current fish spawn operations are assumed to remain in effect and are incorporated in the model through rate of change constraints on the Corps projects and release constraints on Jim Woodruff. Table 2 lists the principal fish spawning periods for each of the Corps projects and for the Apalachicola River.

Table 2. Principal Fish Spawning Periods

Project	Fish Spawn Period
Lake Lanier	01 Apr – 01 Jun
West Point	01 Apr – 01 Jun
Walter F. George	15 Mar – 15 May
Lake Seminole	01 Mar – 01 May
Apalachicola River	01 pr – 01 Jun

b) Fish Passage

Since 2005, each spring (from March through May) the Corps has operated the lock at Jim Woodruff Dam to facilitate downstream to upstream passage of Alabama shad and other anadromous fish (those that return from the sea to the rivers where they were born in order to breed). There are slight differences in the locking technique used each year, but, in general, two fish locking cycles are performed each day between 0800-1600 hours: one in the morning and one in the afternoon. The operation begins with opening the lower lock gates and getting fish into the lock (either by transporting them into the lock by boat (2005), using attraction flows to entice the fish into the lock (2006-07), or by leaving the lower gate open for a period of time before a lock and allowing the fish to move in without an attraction flow (2008). Once the fish are in the lock (or assumed to be in the lock), the downstream doors are closed, the lock is filled to the lake elevation, and the upper gates are opened. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of locks per day will not change. Under the NOAction Alternative, the current fish passage operation is assumed to remain in effect, although no explicit operation is specified for it in the model.

c) The RIOP

In addition to fish spawn management and fish passage operations, the Corps also manages releases from Jim Woodruff Dam to support the federally protected Gulf Sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. This operation is governed by a set of minimum flow and maximum fall rate provisions termed in the RIOP.

The Revised Interim Operating Plan (RIOP) specifies two constraints applicable to the daily releases from Jim Woodruff Dam: (1) a minimum discharge (measured in cubic feet per second [cfs]); and, (2) a maximum fall rate (measured in feet per day [ft/day]). The RIOP includes conditions under which maintenance of the maximum fall rate schedule is suspended and more conservative drought contingency operations begin. The RIOP also places limitations on refill, but does not require a net drawdown of composite storage unless basin inflow is less than 5,000 cfs. A number of state variables (described in detail in Appendix H) are created to report on the conditions that influence the determination of the minimum flows and ramp rates.

(a) Minimum Discharge

The RIOP varies minimum discharges from Jim Woodruff Dam by basin inflow, by composite storage, and by month. The releases are measured as a daily average flow in cfs at the Chattahoochee gage downstream of the dam. Table 3 shows minimum releases from Jim Woodruff Dam prescribed by the RIOP and shows when and how much of basin inflow is available for increasing reservoir storage. The RIOP defines basin inflow threshold levels that vary by three seasons: spawning season (March-May), non-spawning season (June-November), and winter (December-February), and also incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Each of the individual storage reservoirs consists of four Action Zones. The composite conservation storage utilizes the four zone concepts as well. For example, Zone 1 of the composite storage represents the combined storage available in Zone 1 for each of the three storage reservoirs. During the spawning season, two sets of four basin inflow thresholds and corresponding releases exist based on composite storage. When composite storage is in Zones 1 or 2, a less conservative operation is in place. When composite storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing impacts to listed species and critical habitat in the river. When composite storage falls into Zone 4, the drought contingency operations are "triggered" which represent the most conservative operation plan. A detailed description of the drought contingency operations is provided below.

When composite storage is in zone 1-3 and drought contingency operations have not been triggered the normal RIOP releases are determined as follows. During the spawning season, the current composite storage zone and basin inflow are used to determine the minimum release. During the non-spawning season, basin inflow is used. During the winter season, the minimum release is 5,000 cfs while in composite storage Zones 1-3. There are no basin inflow storage restrictions as long as this minimum flow is met under these conditions. When composite storage falls into Zone 4, the drought contingency operations of the RIOP are "triggered".

The flow rates included in Table 3 prescribe minimum releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the RIOP minimum release provisions may occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydropower or flood control.

Table 3. RIOP Minimum Releases from Jim Woodruff Dam

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage[1]
March – May (Spawning season)	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June – November (Non-spawning season)	Zones 1, 2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December – February (Winter)	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4 Or Drought Ops	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	>= 4,500[2]	Up to 100% BI > 4,500

[1] Consistent with safety requirements, flood control purposes, and equipment capabilities.
[2] Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/day drop.

(b) Maximum Fall Rate

Fall rate, also called down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. The fall rates are expressed in units of ft/day, and are measured at the Chattahoochee gage as the difference between the daily average river stages of consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The RIOP maximum fall rate schedule is provided in Table 4. When composite storage is in Zone 4 and the drought contingency operation described below is implemented, the maximum fall rate schedule is suspended. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the basin inflow.

Table 4. RIOP Maximum Fall Rate Schedule

RIOP Maximum Fall Rate Schedule for Composite Storage Zones 1, 2, and 3*	
Release Range (cfs)	**Maximum Fall Rate (ft/day), measured at Chattahoochee gage**
> 30,000**	No ramping restriction***
> 20,000 and <= 30,000*	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and <= 20,000*	0.5 to 1.0
Within Powerhouse Capacity and > 10,000*	0.25 to 0.5
Within Powerhouse Capacity and <= 10,000*	0.25 or less

* Maximum fall rate schedule is suspended in Composite Zone 4
** Consistent with safety requirements, flood control purposes, and equipment capabilities.
*** For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control down ramping rate. Therefore, no ramping rate is required.

During the spawning period (March – May), the Corps manages releases from Jim Woodruff Dam to avoid potential sturgeon take. Potential sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., today's stage is equal to or greater than 8 feet lower than the stage during any of the previous 14 days) when flows are less than 40,000 cfs.

The fall rates used in the ResSim model for the 2008 Biological Opinion (BiOp) and the 2011 Biological Assessment (BA) followed the maximum fall rate schedule. However, the Corps believes that when flows are less than 10,000 cfs, the observed fall rates are more conservative than those reflected in the model due to the limitations of the equipment and careful operations to avoid violating the maximum fall rate schedule. Because the model has limited ability to represent the actual down-ramping operations, USFWS requested that the Corps simulate the RIOP using a fall rate they believed to be more representative of actual operations. The RIOP continues to prescribe fall rates of <0.25 ft/day for releases less than 10,000 cfs, but the model simulates the RIOP using a standard 0.13 ft/day fall rate, which is the average fall rate in this range of flows since the Corps implemented the maximum fall rate schedule in September 2006. This is consistent with previous simulations for the 2008 BiOp (and currently for the 2012 BiOp (USFWS,2012)) that use a slightly higher minimum flow than 5,000 cfs (5,050 cfs) in the model simulation rules to better reflect actual conservative operations in place to avoid violating the 5,000 cfs minimum flow provision.

(c) Drought Contingency Operations

The RIOP incorporates a drought contingency operation (referred to as the drought plan) that specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite storage within the basin is replenished to a level that can support them. Under the drought plan, the minimum discharge is determined in relation to composite storage and not average basin inflow. The drought plan is "triggered" when composite storage falls into Zone 4. At that time all the Zone 1-3 composite storage provisions (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) are suspended as shown in Table 5, and management decisions are based on the provisions of the drought plan. The drought plan also includes a temporary waiver from the existing water control plan to allow temporary storage above the winter pool rule curve at the Walter F. George and West Point projects if the opportunity presents itself and/or begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs as well as provide a minimum release less than 5,000 cfs from Jim Woodruff Dam.

Table 5. Provisions Suspended During Drought Operations

Seasonal storage limitations
Maximum fall rate schedule
Minimum flow thresholds

The drought plan prescribes two minimum releases based on composite storage in Zone 4 and an additional zone referred to as the Drought Zone (Figure 12).

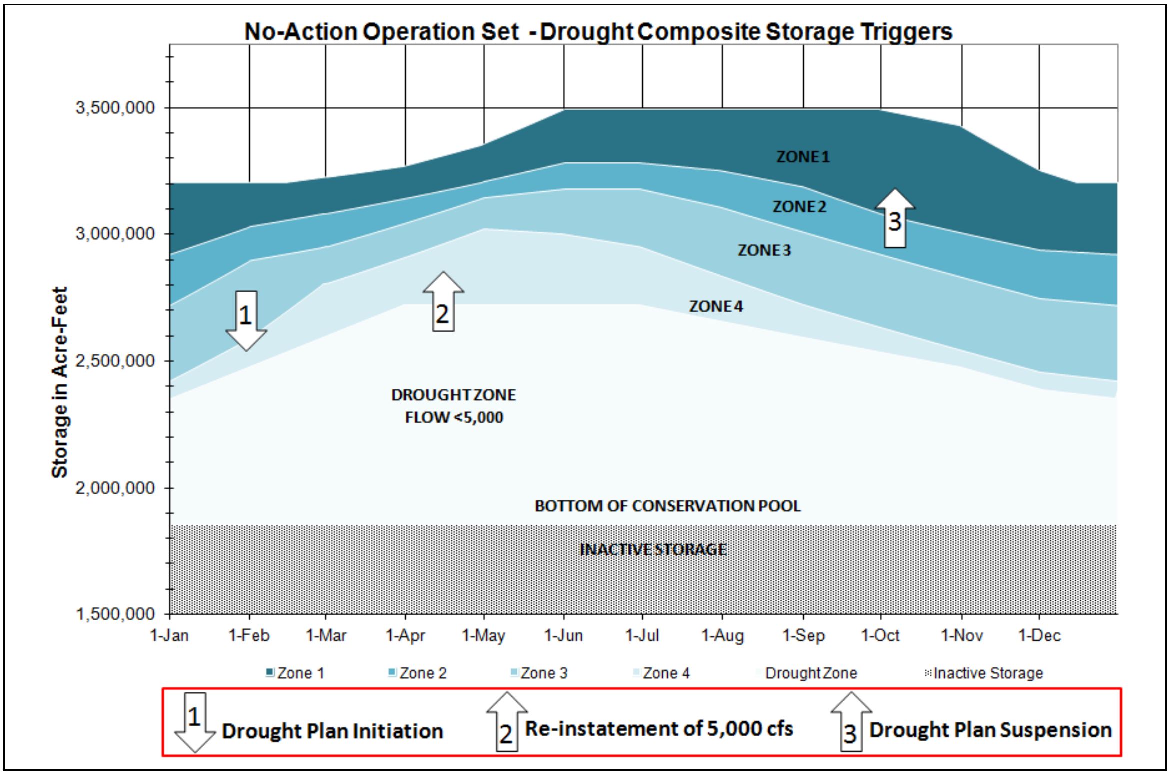

Figure 12. RIOP – Drought Composite Storage Triggers

The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Buford, West Point and Walter F. George reservoirs plus Zone 4 storage in Buford. The Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs, and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs, and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a drop of 0.25 ft/day. The 4,500 cfs minimum release is maintained until composite storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated. The drought plan provisions remain in place until conditions improve such that the composite storage reaches a level above the top of Zone 2 (i.e., within Zone 1). At that time, the temporary drought plan provisions are discontinued, and the normal provisions are re-instated. During the drought contingency operations a monthly monitoring plan that tracks composite storage in order to determine water management operations (the first day of each month represents a decision point) is implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts are used when determining the set of operations to utilize in the upcoming month.

Although the drought plan provides flows lower than 5,000 cfs in the river, incorporation of provisions which allow for reduced flows during the refill period when system storage is lower and storage conservation measures when composite storage is in Zone 4 should result in fewer occasions when these low flows are triggered or where storage shortages result in flows less than 5,000 cfs.

For further details on the foregoing, see the discussion “Environmental Flows for Endangered Species Conservation” in Section 2.1.1.2.3.7, Water Control Objectives and Guidelines (USACE, 2011).

The RIOP is represented in NOAction alternative through a complex set of scripted state variables, if blocks, and rules. Details of this can be found in Appendices E and H.

3. Navigation

The existing ACF Navigation project (Walter F George, George Andrews, and Jim Woodruff projects) authorizes a 9-foot deep by 100-foot wide waterway from Apalachicola, Florida to Columbus, Georgia, on the Chattahoochee River, and to Bainbridge, Georgia on the Flint River. Conditions on the Apalachicola River have been such in recent years that a 9-foot deep channel has not been available for much of the year. In the 1990s, due to deteriorating channel conditions and limited channel availability, navigation windows were routinely scheduled during the low flow months. Navigation windows were comprised of storing water in the upstream reservoirs for several weeks, and then making increased releases for a 10-day to 2-week period to allow commercial barge navigation to make a round-trip up river for scheduled delivery of commodities. Concerns were raised regarding the fluctuations of both reservoir and river stages associated with navigation window releases, and the continued use of navigation windows became increasingly controversial, especially during sustained low flow periods when observed fluctuations were more extreme. As a result of fluctuating river stages during navigation windows, gradual ramping rates were developed in coordination with the USFWS and Florida Fish and Wildlife Conservation Commission, with the goal to provide down-ramping rates of no more than ½ foot per day during fish spawn activities, and no more than one foot per day during other periods of the year, whenever flows were below 20,000 cfs. The last navigation window was provided in the spring of 2000, and precipitated complaints that the navigation window was scheduled during the period of fish spawn and had adversely impacted both reservoir and riverine fish spawn activities. No navigation windows have been scheduled since that time, and none are planned in the foreseeable future. Dredging on the Apalachicola River was also reduced since the 1980s due to a lack of adequate disposal area capacity in certain reaches of the river. No dredging was conducted in 2000 or 2002 due to sustained drought conditions in the basin, and only very limited dredging was conducted in 2001 and then shutdown due to sustained low flow conditions. No dredging has been conducted since that time, for a variety of reasons related to flow or funding levels, and currently has been indefinitely deferred due to denial of a Section 401 water quality certificate from the State of Florida and recent congressional language that limits funding for dredging operations in the ACF basin. The lack of dredging and routine maintenance has led to inadequate depths in the Apalachicola River navigation channel, and commercial navigation is only possible on a seasonal basis when flows in the river are naturally high, with flow support for navigation suspended during drier times of the year. Currently, specific navigation operations occur on a case-by-case basis, with limited releases for navigation being made for special shipments when a determination can be made that other project purposes will not be significantly impacted and any fluctuations in reservoir levels or river stages will be minimal.

Although the current operations of the ACF system continue to attempt to support navigation as described above, the NOAction alternative has no explicit operation for navigation.

4. Hydroelectric Power

The Buford, West Point, Walter F. George, and Jim Woodruff projects include hydroelectric power plants. The total generation capacity of these four (4) ACF plants is 336 megawatts. Through the Department of Energy's Southeastern Power Administration (SEPA), these power plants provide power to over 300 preference customers throughout the Southeastern United States. In 2005, the ACF hydroelectric power plants generated nearly 1.1 million megawatt-hours, enough electricity to supply approximately 110,000 households in the region. In 2006 the same power plants generated approximately 717,178 megawatt-hours which supplied approximately 70,000 households. The decrease in generation was due to a combination of equipment outages and sustained drought conditions. Hydroelectric power generation is achieved by passing flow releases to the maximum extent possible through the turbines at each project, even when making releases to support other project purposes. The Buford, West Point, and Walter F. George projects are operated as "peaking plants", and provide electricity during the peak demand periods of each day and week. Hydropower peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines.

A reduction of generation based on different operation zones was implemented as shown in Table 6.

Table 6. Buford, West Point and Walter F George Dam Hydropower Generation Schedule

Action Zones	Buford Generation (hrs)	West Point Generation (hrs)	Walter F george Generation (hrs)
Flood Control	3	4	4
Conservation	3	4	4
Zone 2	2	2	2
Zone 3	2	2	2
Zone 4	0	0	0

During dry periods, as the lake levels drop below Zone 1, hydroelectric power generation is reduced proportionally as pool levels decline to as low as 2 hours per day generation at each "peaking plant" project during low flow conditions. Peak generation may be eliminated or limited to conjunctive releases during severe drought conditions.

In addition to power generation being governed by Action Zones, there are also physical limitations that factor into power generation decisions. The main hydropower units and small house unit intakes at Buford Dam/Lake Lanier are located at elevation 919 feet above mean sea level (msl). However, severe cavitations occur in the main hydropower units when the water surface falls to 1,035 ft msl or below, at which time the units are taken out of service and generation ceases. The small house unit goes off line when water elevations reach 1,020 ft msl or below Releases can occur through the sluice values down to elevation 920 ft msl.

Because it does not have the ability to store appreciable amounts of flow, the Jim Woodruff plant is operated as a "run-of-river" plant where inflows are passed continuously and electricity is generated around the clock. The current RIOP includes a limited hydropower peaking operation at Jim Woodruff Dam when daily average releases are less than the combined capacity of the powerhouse turbines (about 16,000 cfs) in order to deliver extra power during hours of peak demand for electricity. These peaking releases are included in the daily average discharge computations for the RIOP minimum flow provisions. The peaks are also included in the stage computations for the RIOP maximum fall rate schedule; however, the maximum fall rate schedule addresses the difference between the average river stages of consecutive calendar days, not the shorter-term differences that result from peaking operations within a calendar day. The current RIOP includes a provision that discontinues peaking operations at the Jim Woodruff plant as average daily releases approach 6,000 cfs, in order to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement.

Under the NOAction Alternative, the current hydroelectric power generation operations are implemented as indicated in Table 6.

5. Water Supply

Various municipal and industry (M&I) entities withdraw water directly from Lake Lanier and others withdraw directly from the Chattahoochee River downstream of Lake Lanier. Operations are also influenced by agricultural water withdrawals on the Flint River. Agricultural demands vary depending on the climatic conditions, but are generally 1.5 to 2 times the withdrawals for M&I. Water withdrawals within the State of Georgia are made pursuant to water withdrawal permits issued by the Georgia Department of Natural Resources. Previous water supply contracts issued by the Corps for withdrawals from Lake Lanier expired by 1990 and have not been re-issued. The Water Supply Act of 1958 provides authority for reallocation or addition of storage within Corps reservoirs for water supply, with the cost of storage and associated facilities to be reimbursed by a non-Federal entity via water storage contracts. No storage within the ACF projects is currently allocated to water supply.

Water management for the water supply/water quality function involves taking water from storage, either directly from the reservoir or through dam releases for downstream interests. These operations ensure that sufficient drinking water is available for municipal and industrial needs and agreements to provide instream flow for water quality are not violated. Releases from projects in the system are the minimum (capacity) release for hydropower or releases needed for basin-wide water supply/water quality. The current water supply users withdrawing water directly from Lake Lanier and their 2006 withdrawal amounts are as follows:

Gwinnett County:	92.57 million gallons per day (mgd)
City of Gainesville:	18.98 mgd (includes 8.0 mgd relocation amount)
City of Cumming:	11.93 mgd
City of Buford:	1.53 mgd

In general, Lanier weekly water supply/quality release decisions are based upon the Chattahoochee River Management System (as recorded in the Apalachicola Basin Reservoir Regulation Manual, Appendix B). In coordination with ARC(Atlanta regional commission) and Georgia Power, the Corps calculates the sum of anticipated downstream water supply river withdrawals by DeKalb County, City of Atlanta, Cobb County/Marietta Water Authority and Fulton County (average annual 291 mgd in 2000), water quality releases to ensure 750 cfs at the Peachtree Creek gaging station, and water returns minus inflows between Buford Dam and Peachtree Creek. This approach ensures sufficient water is released from Lake Lanier to allow for Chattahoochee River withdrawals while also meeting the 750 cfs requirement at Peachtree Creek, along with satisfying hydropower demands and fish and wildlife needs. During the winter and spring, releases from Lanier may be reduced due to sufficient downstream tributary flows to meet the Georgia Environmental Protection Division's 750 cfs target water quality flow at Peachtree Creek. To the extent possible, these releases are made in conjunction with peaking power operations in order to minimize impacts to hydropower generation.

Over 40% of Lake Lanier's water is located in the "inactive" storage zone (below elevation 1035 msl). All the water supply users have multiple level intakes in Lake Lanier (in the conservation pool and inactive storage), and several withdraw water from the inactive storage. Gwinnett County has multiple elevation intakes ranging from 1062, 1045, and 1025, and has withdrawn from the 1025 intake (within the inactive storage zone) for many years. The City of Cumming intakes range from elevation 1053 down to elevation 1032. The City of Buford intakes are at elevations 1062, 1052, 1042, and 1032. The City of Gainesville has three intake structures, each with multiple intake ports ranging from elevation 1063 down to elevation 1025. Releases through Buford Dam plus some small local runoff make up the Chattahoochee River that flows downstream to the Atlanta area. The releases from Lake Lanier support the Atlanta municipal water supply and the M&I water supply needs of the Cities of LaGrange, West Point, and Columbus as well as a number of industries.

Under the NOAction Alternative, the current water supply demands are represented as diversions and negative local inflows as described is section II.B and the quantity of these demands reflect the 2007 level withdrawals.

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-B, Method 1) and reaches (Section II-B, Method 2) are listed in Table 7.

Table 7. List of Diversions Modeled in ResSim

Diversion	Description
Reservoir Diversions (Method 1)	
Metro Atlanta	Diversion from Buford_IN inflow node
Bear Creek-diverted outlet	Diversion from Bear Creek reservoir to Chattahoochee River
West Point_DIV	Diversion from West Point_IN inflow node
Bartletts Ferry_DIV	Diversion from Bartletts Ferry_IN inflow node
Walter F George_DIV	Diversion from Walter F George_IN inflow node
George Andrews_DIV	Diversion from George Andrews_IN inflow node
Jim Woodruff_DIV	Diversion from Jim Woodruff_IN_SP_IN inflow node
Reach Diversions (Method 2)	
Albany_Divs	Albany diversion
Atlanta Divs_River	Composite of the river withdrawals between Morgan Falls Dam tailrace and Peachtree Creek confluence
Bainbridge_Divs	Bainbridge diversion
Blountstown_Divs	Blountstown diversion
Columbus_Divs	Columbus diversion
Griffin_Divs	Griffin diversion
Montezuma_Divs	Montezuma diversion
Newton_Divs	Newton diversion
Non-Metro Atlanta_Divs	Chattahoochee_HW diversion
Sumatra_Divs	Sumatra diversion
To Bear Creek	Diversion from Chattahoochee River to Bear Creek Reservoir
To Glades	Diversion from Chattahoochee River to Glades Reservoir
US Bear Creek_Divs	US Bear diversion
West Point Gage_Divs	West Point Gage diversion
Whitesburg_Divs	Whitesburg diversion

6. Water Quality

Buford, West Point, and Jim Woodruff Dams all include water quality operations to provide continuous minimum flow releases. Walter F. George has no minimum flow provision; however, when low dissolved oxygen (DO) values are observed below the dam, spillway gates are opened until the DO readings return to an acceptable level. Occasional special releases are also made at Buford to ensure adequate DO and water temperature at the Buford Fish Hatchery located downstream of the dam. Additionally, self-aspirating turbines were recently installed at Buford to improve DO levels downstream. At Buford Dam the small turbine-generator is run continuously to provide a minimum flow from the dam which ranges up to approximately 600 cfs. At West Point Dam, a similar small generating unit provides a continuous release of approximately 675 cfs. In addition to these flows, Buford Dam is operated in conjunction with the downstream Georgia Power Dam at Morgan Falls to ensure a minimum instream flow of 750 cfs on the Chattahoochee River at Peachtree Creek to meet State water quality commitments. A 5,000 cfs minimum flow is maintained as a release from Jim Woodruff Dam to the Apalachicola River, which assures an adequate water supply for downstream industrial use and presumably water quality. No water quality problems below Jim Woodruff Dam have been identified in association with project operations.

Although there is no Corps requirement to maintain minimum flows for assimilative capacity at Columbus, GA, the Georgia Power projects above Columbus are required in their Federal Energy Regulatory Commission (FERC) licenses to provide 1,850 cfs weekly average, 1350 cfs daily average, and 800 cfs instantaneous minimum flow at Columbus. Releases from the Georgia Power projects are dependent on upstream releases from West Point Dam and to a limited extent these requirements are considered when making release decisions for West Point Dam. Georgia Pacific and Farley Nuclear Plant located below George W. Andrews Dam have stated a requirement of 2,000 cfs for assimilative capacity needs. Although this is also not a Corps requirement, to the extent practicable, these needs are considered in operations at Walter F. George and Jim Woodruff Dams. Under the NOAction Alternative, the current water quality operations are represented with minimum flow releases from Buford, West Point, and Jim Woodruff.

7. Recreation

All of the Corps lakes have become important recreational resources on the ACF system. The five Corps projects in the basin account for 235,291 total acres of land and water. A wide variety of recreational opportunities are provided at these lakes including boating, fishing, picnicking, sightseeing, water skiing, and camping. These reservoirs support popular sport fisheries, some of which have achieved national acclaim for trophy-size catches of largemouth bass. Of these projects, Lake Lanier (Buford Dam) is one of the most visited Corps of Engineer lakes in the entire United States with over 7.7 million visitors in 2005. The West Point and Walter F. George lakes had over 3.1 and 3.6 million visitors respectively in 2005 to also rank among the top ten most visited Corps lakes in the United States. In addition, the Jim Woodruff (Lake Seminole) had over 1.2 million visitors in 2005, and the smaller George W. Andrews project 269,000 visitors. The economic benefits of recreation at the lakes is significant resulting in visitor spending in 2005 of over $125 million at Lake Lanier, $36 million at West Point, and $111 million at Walter F. George. Recreation benefits are maximized at the lakes by maintaining full or nearly full pools during the primary recreation season of 1 May through 8 September. In response to meeting other authorized project purposes, lake levels can and do decline during the primary recreation period, particularly during drier than normal years.

Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 8).

Table 8. Recreation Impact Levels

Corps Project	First Impact Level	Second Impact Level
Lake Lanier (msl)	1066	1063
West Pont (NGVD)	632.5	629
Walter F. George (NGVD)	187	185
Lake Seminole (msl)	76	NA

The first impact level is generally characterized by marginal impacts to designated swimming areas, increased safety awareness regarding navigation hazards, minimal impacts to Corps boat ramps, and minimal impacts to private marina and dock owners. More substantial impacts begin to occur at the second impact level.

When pool levels must be lowered, the rates at which these draw-downs occur are as steady as possible. The action zones are drawn to correlate the line between Zone 2 and Zone 3 to the Initial Impact Level (IIL), at the beginning of the recreation season (May through early September). If lake levels fall to Zone 3 during the recreation season then releases are normally limited to 2-hours-a-day generation and minimal navigation support, which tends to stabilize the lake levels until the end of the season. Under the NOAction alternative the recreation impact levels are represented through the use of the current action zones as described in this section and section II.F.

The implementation of the "NOAction" Alternative in the HEC-ResSim model is described in Appendices A through G.

IV. Description of Alternatives

A. Process of Developing Alternatives

In the process of updating the draft 1989 Master Water Control Plan to incorporate a drought contingency plan and the RIOP, the Corps aims to implement minor revisions to the water management procedures to improve overall performance of the ACF System. A combination of stakeholder comments and operational experience was used to define objectives in the development of the updated Master Manual. This iterative process is illustrated in Figure 13.

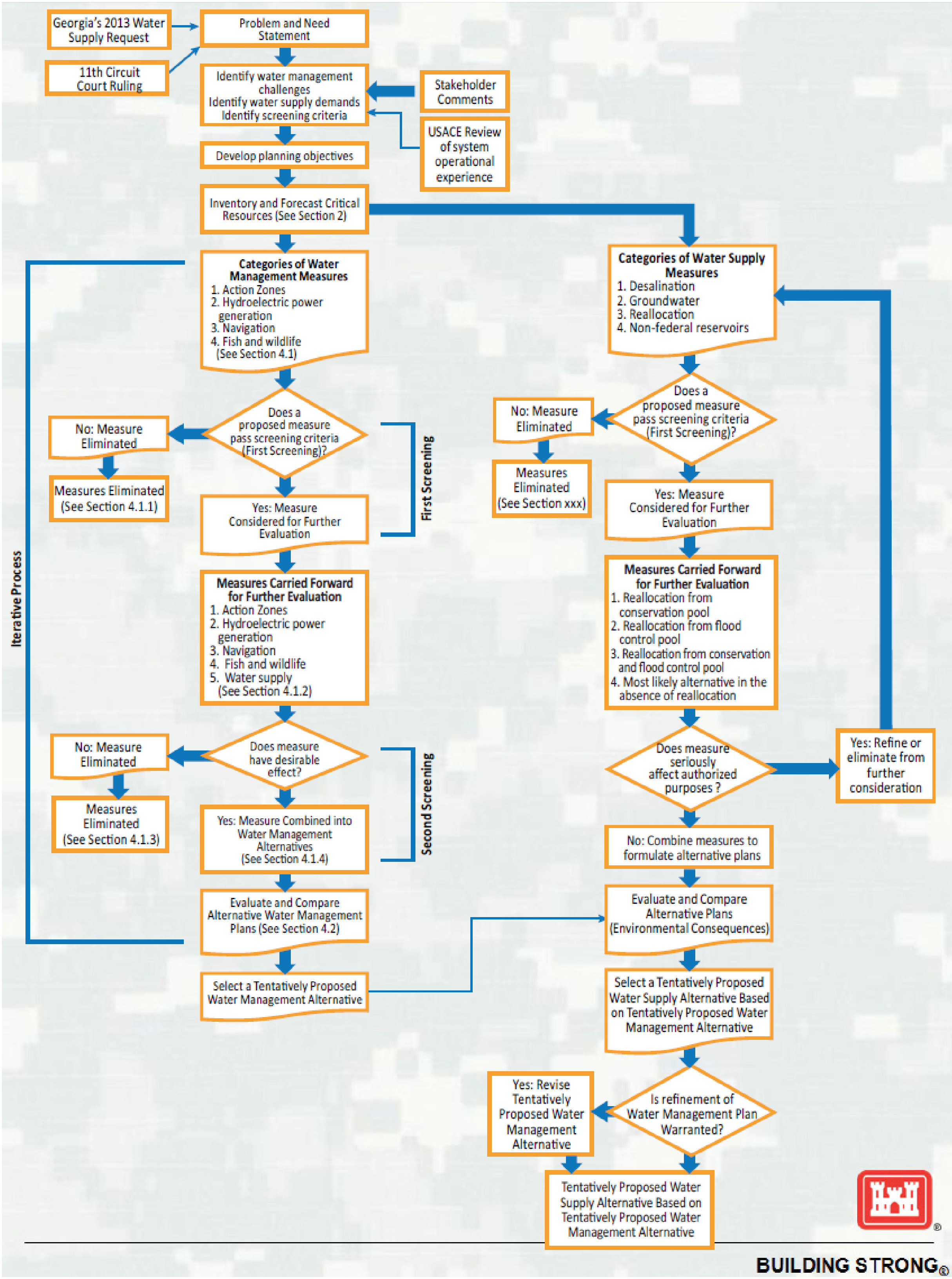

Figure 13. Process of Formulating Management Measures

Based on operational experience gained between 1989 and the present time, the following challenges were identified:

- The basis for the action zone boundaries established in the draft 1989 Master Water Control Plan was not easily explained. These zones were based on experience gained in the 1980's in responding to droughts and attempting to support navigation on the system. Additional experience has been gained in operating for drought conditions, threatened and endangered species, and the navigation on the system is considerably different from that in the 1980's. Operational decisions based on the 1989 action zones were shown to have disproportionate impact on reservoir levels.
- When operating under the 2012 RIOP and recovering from drought conditions, a premature resumption of normal operations increases the chances of quickly returning to drought operations which increases the chances of triggering exceptional drought operations and thus reducing flows downstream of Jim Woodruff Dam to less than 5,000 cfs.
- Sustained hydropower operations during drought have an adverse effect on the Corps' ability to continually operate for endangered species.
- Navigation on the Apalachicola River is not dependable.

Based on these operational challenges, extensive stakeholder input, and the implications of the Federal Court's 2011 ruling on water supply as an authorized project purpose (*MDL-1824 Tri-State Water Rights Litigation*), the PDT identified numerous potential operational measures for implementation in the updated Water Control Manual (WCM). The measures evaluated included revising: reservoir drawdown and refill periods, action zones, proportional balancing of zone drawdowns among projects; hydropower generation schedules; water supply operations; drought procedures and environmental flows; and navigation-specific operations.

The Corps used an iterative process to determine which of the various measures would be further developed, analyzed, and refined. This process is illustrated in Figure 14. Using HEC-ResSim, a wide array of alternatives were developed to simulate the effects of changing and incorporating individual and multiple operational measures at individual reservoirs and across the entire ACF System. The impacts from different alternatives were evaluated in terms of project criteria such as flood damage reduction, generation capacity, navigation availability, fish and wildlife conservation, recreation, water quality and water supply. Ultimately, the recommended plan represents the combination of measures that best meets the desired objectives while balancing system storage.

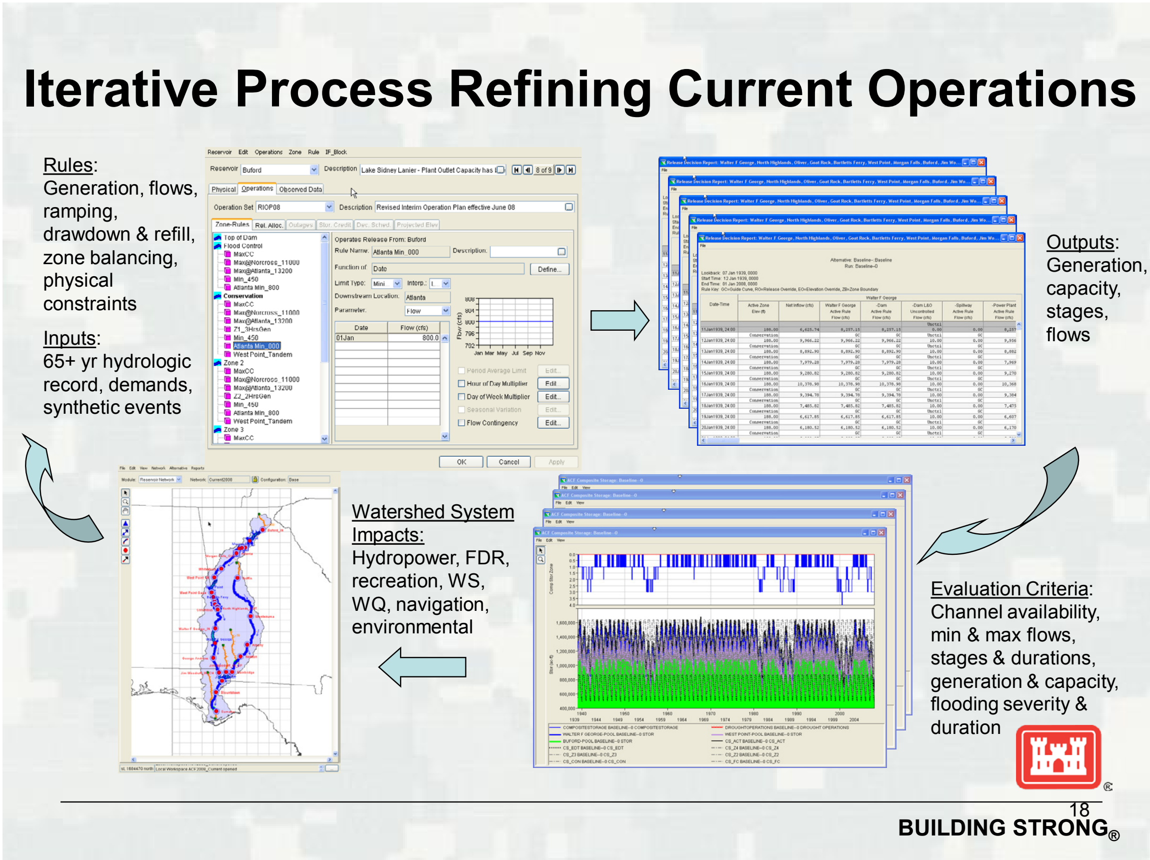

Figure 14. Process of Refining Current Operations

The following sections outline the operational measures implemented and evaluated using ACF system model. Appendix K provides details of all the modeled alternatives.

B. Measures / Components of Alternatives

The recommended plan includes a combination of measures designed to improve overall performance of the ACF System. The operational measures evaluated in the formulation of alternatives were in compliance with the purpose and needs of the federal projects in the system. The formulation process evaluated the following measures for the recommended plan.

1. Revised Action Zones

The action zones for Lake Lanier, West Point Lake, and Walter F. George Lake, were originally developed using past experience in water management with consideration to the time of year, relationship of historic pool levels and water releases, operational limits for conservation, and recreational impacts. The Corps tries to operate the projects in balance with each other, to ensure that all the projects are in the same action zone concurrently.

The individual project action zones that comprise the system composite action zones were modified at Buford, West Point and Walter F. George to incorporate recent operational experience. The action zones were revised by altering the summer and winter levels, based on the refill capability of each project and an equitable relative change in lake level. West Point and Walter F. George are more likely to refill each year than Buford. Consequently, a greater percentage of their conservation storage contributes to the upper composite storage zones.

The winter levels of the action zones are tied to recreation impact and hazard levels for all three reservoirs with a 0.5 ft buffer. Summer level adjustments are affected by proportioning the individual project storage contribution to the composite storage zone based on each project's drainage area. This works well for Zone 1 and 2 and to a certain extent for Zone 3. In composite storage Zone 4, however, the system is under stress and Lake Lanier contributes 78% of the system storage to composite Zone 4 reserving the bulk of the storage for drought operations support to the largest headwater project which also has the smallest drainage area. The summer zones for Buford were modified to increase the composite storage while the non-summer period of the lower action zones were raised to enhance the refill capability by reducing demands.

A linear foot-for-foot drawdown relationship was created between West Point and Walter F. George for the upper action zones. This concept supports using storage from the lower projects first, during normal and initial drought conditions. During severe droughts, Buford will support the majority of the system demands. The lower action zone elevations at West Point and Walter F. George were not changed to reflect a linear drawdown relationship.

Figure 15 shows the final summer pool comparison of drainage area, storage contributions, and elevation ranges for Buford, West Point and Walter F. George reservoirs for the four action zones.

Action Zones, Summer Pool Storage Comparison

Buford — % of Drainage Area Comparison

1-Jun	Buford	West Pt	George	Buford	West Pt	George	Total
	elev	elev	elev	dsf	dsf	dsf	
Top1	1071.00	635.0	190.0	985747	304782	471093	
Bott1	1068.00	632.5	187.5	928776	273478	416593	
Diff.	3.00	2.5	2.5	56971	31304	54500	142775
				39.90%	21.93%	38.17%	% Zone 1
				14.19%	30.15%	55.66%	% drainage area

Elevation range same for West Point & WF George

1-Jun	Buford	West Pt	George	Buford	West Pt	George	Total
	elev	elev	elev	dsf	dsf	dsf	
Top2	1068.00	632.5	187.5	928776	273478	416593	
Bott2	1066.50	632.0	187.0	901021	267453	406106	
Diff.	1.50	0.5	0.5	27754	6025	10487	44266
				62.70%	13.61%	23.69%	% Zone 2
				14.19%	30.15%	55.66%	% drainage area

Elevation range same for West Point & WF George

1-Jun	Buford	West Pt	George	Buford	West Pt	George	Total
	elev	elev	elev	dsf	dsf	dsf	
Top3	1066.50	632.0	187.0	901021	267453	406106	
Bott3	1065.00	631.0	186.3	873771	255784	392025	
Diff.	1.50	1.0	0.7	27250	11669	14081	53001
				51.41%	22.02%	26.57%	% Zone 3
				14.19%	30.15%	55.66%	% drainage area

1-Jun	Buford	West Pt	George	Buford	West Pt	George	Total
	elev	elev	elev	dsf	dsf	dsf	
Top4	1065.0	631	186.3	873771	255784	392025	
Bott4	1035.0	620	184	437415	150441	347875	
Diff.	30.0	11.0	2.3	436356	105343	44150	585849
				74.48%	17.98%	7.54%	% zone 4
				14.19%	30.15%	55.66%	% drainage area

Drainage Area

Buford	West Pt	George	Total
1040	2210	4080	7330

Figure 15. Final Summer Pool Storage Comparison of Action Zones at Lanier, West Point, and Walter F. George

The Corps explored the feasibility of adjusting the size of the action zones at Lake Lanier, West Point Lake, and Walter F. George Lake based on the proportion of reservoir storage to the relative size of the contributing watershed at each project. In refining the action zones the timing of three parameters were evaluated: transition from summer to winter pool levels, proportionality of fill and drawdown relative to each zone, and refill capability of each storage project.

The action zones were refined to minimize the differential in drawdown among the reservoirs when operating in Zone 1. At Buford, Zones 1, 2 and 3 were adjusted to reflect Buford's proportionally small contributing watershed size and its historic operations to meet system demands (the conservation storage in Lake Lanier is much higher than either of the other two system projects, resulting in Buford having a greater contribution to the composite storage.) In refining the action zones, the boundaries were revised upward in the winter months at Lake Lanier and at West Point Lake and downward in the summer months at Walter F. George Lake. The revised actions are shown in Figure 16, Figure 17, and Figure 18. The new zones fulfill the objectives of putting the greater burden of the system demands on the lower two reservoirs when in the upper action zones and on Lanier when the system reaches drought operation.

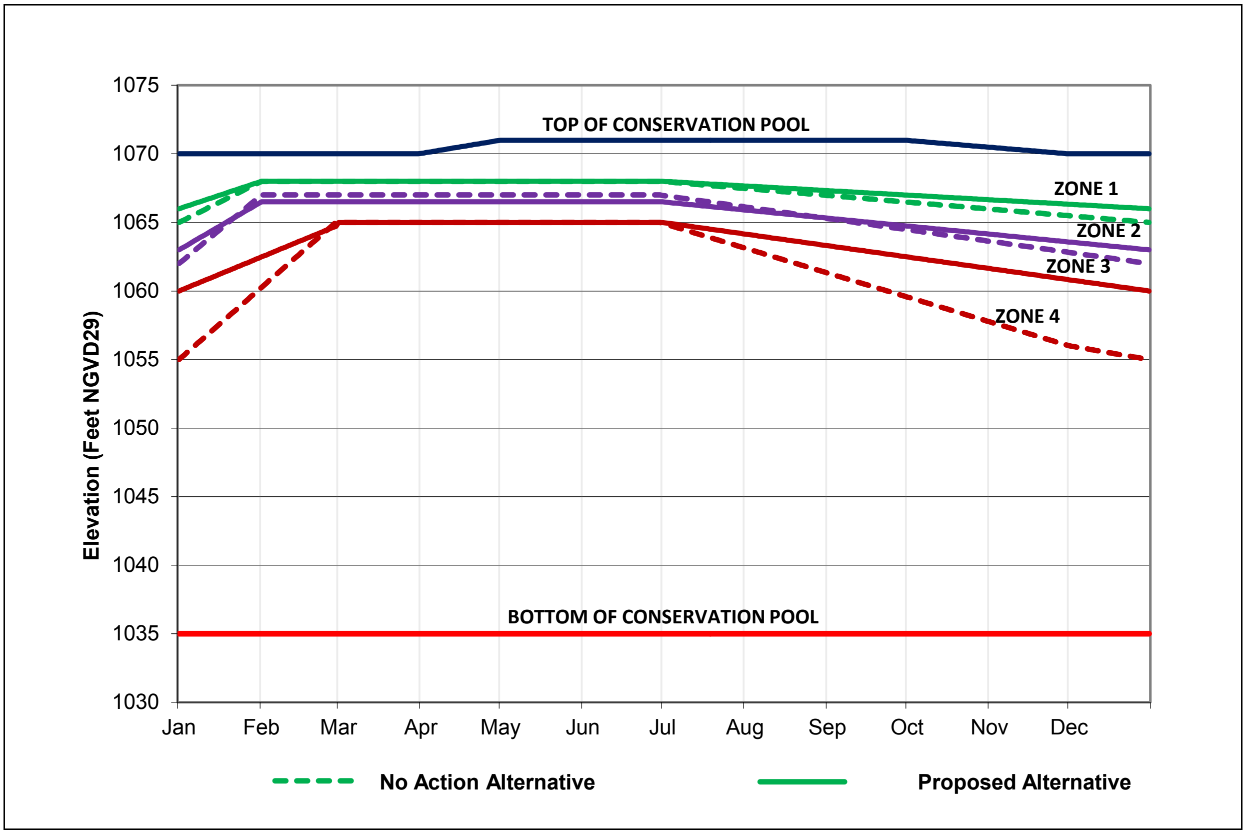

Figure 16. Lake Lanier Water Control Action Zones

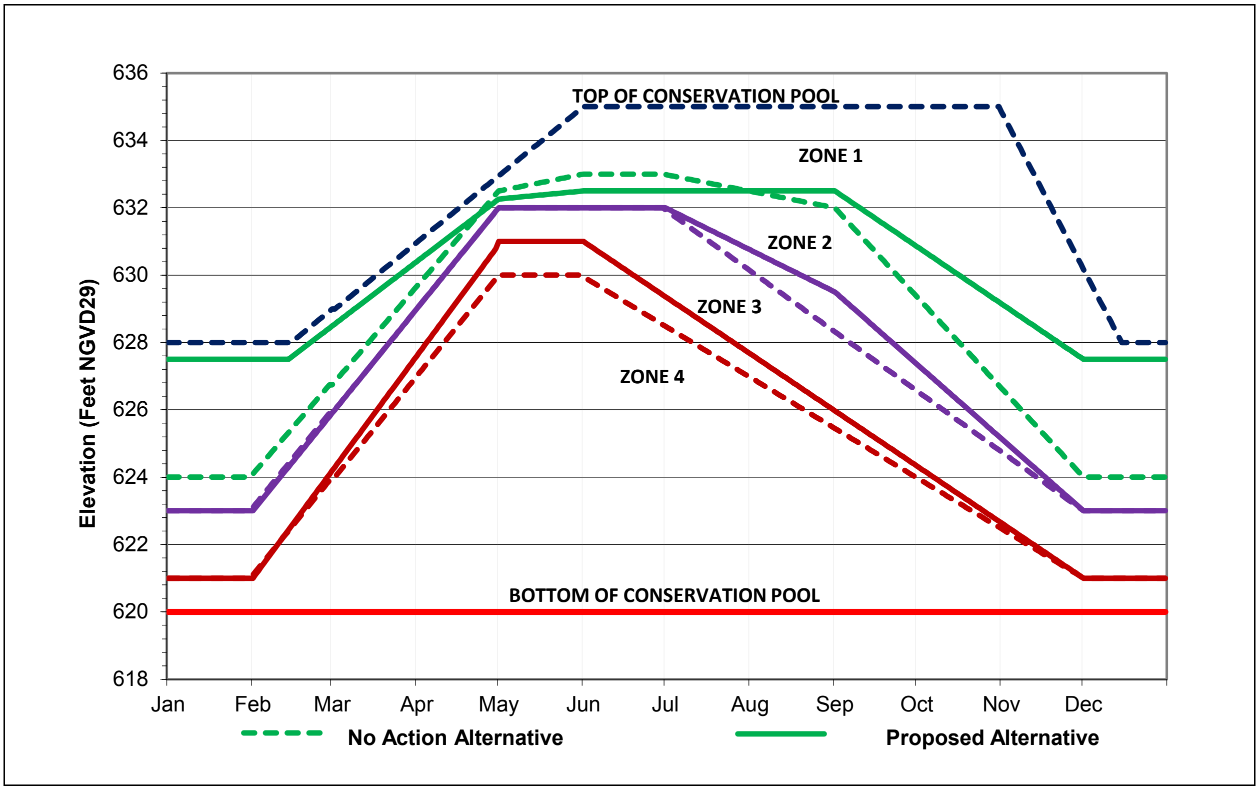

Figure 17. West Point Water Control Action Zones

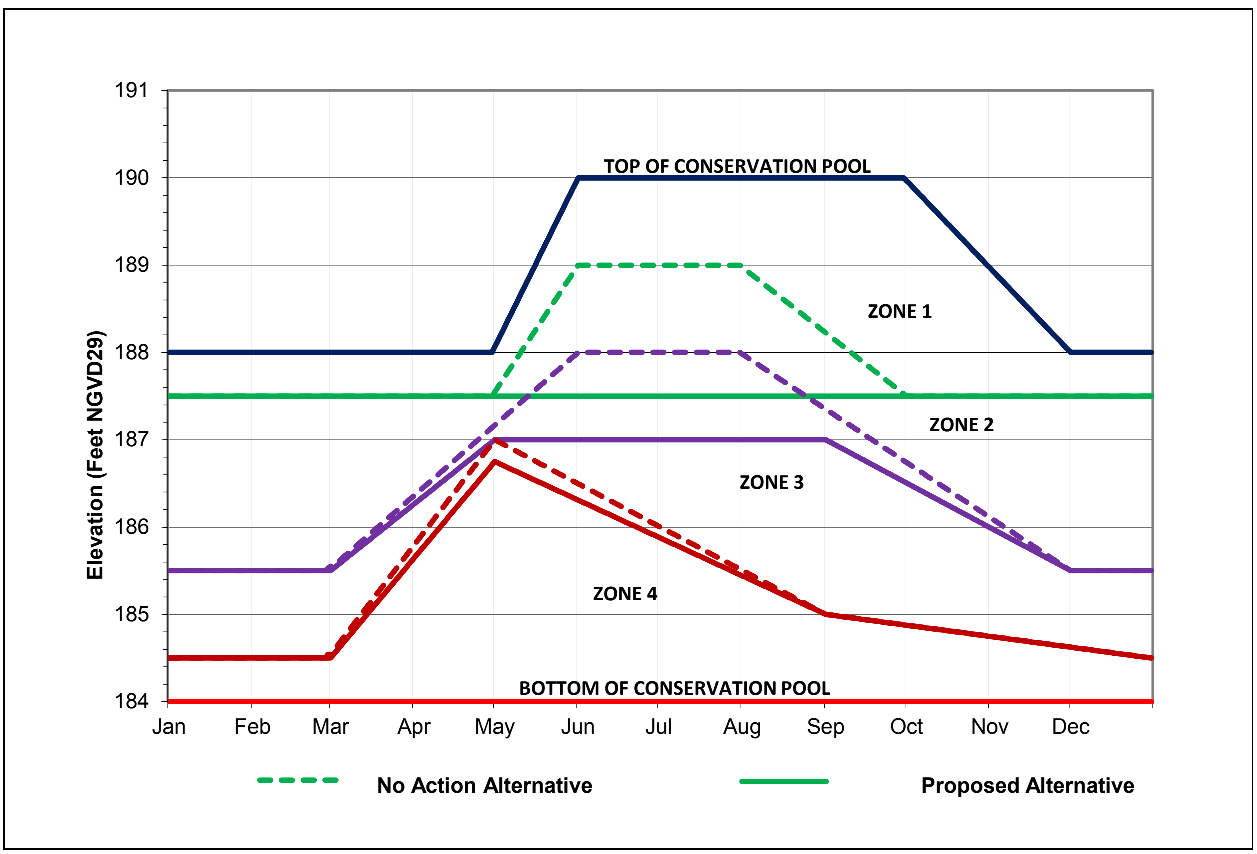

Figure 18. Walter F. George Water Control Action Zones

2. Operations for Threatened and Endangered Species

Operations measures for support of threatened and endangered species were coupled with measures for drought contingencies because low flow conditions are critical to both project purposes. Modifications to the RIOP were based on experience gained since its implementation on June 1, 2008 and centered around two major concepts. The first was to reduce the likelihood of Jim Woodruff releasing less than 5,000 cfs. The minimum discharge from Jim Woodruff Dam is determined in relation to composite conservation storage and not average basin inflow under the drought plan. Secondly, once drought operation has begun, the system requires time to recover before resuming normal operations so that it will not return to drought operations prematurely. The modified composite storage triggers are shown in Figure 20. All modifications to the RIOP are summarized in Table 9 and Table 10 and are listed below:

- Lower the system drought zone to the proposed composite storage level (Emergency Drought Operation zone) developed by USFWS.
- Revise Ramping Rate above Jim Woodruff powerhouse capacity to match the day's basin inflow fall rate and follow the basin inflow fall rate within the physical limits of the project (i.e. spillway gate movement). No ramping rate restrictions when basin inflow is greater than 30,000 cfs.
- Move drought plan suspension to Zone 1 from Zone 2.
- Redraw composite storage zones using the revised project action zones.
- Reduce the hydropower demand when drought operations are triggered and resume normal hydropower demand when drought plan is suspended.

The modified RIOP incorporates a drought contingency operation that specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum releases and maximum fall rate provisions until composite conservation storage in the basin is replenished to a level that can support them.

Table 9. Modified RIOP Flow Requirements

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage*
March – May (Spawning season)	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June – November (Non-spawning season)	Zones 1, 2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December – February (Winter)	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4 or Drought Ops	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	>= 4,500**	Up to 100% BI > 4,500

* Consistent with safety requirements, flood control purposes, and equipment capabilities

** Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/day drop.

Table 10. Modified RIOP Ramping Rates

RIOP Maximum Fall Rate Schedule for Composite Storage Zones 1, 2, and 3*	
Release Range (cfs)	**Maximum Fall Rate (ft/day), measured at Chattahoochee gage**
> 30,000**	No ramping restriction***
> 20,000 and <= 30,000*	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and <= 20,000*	0.5 to 1.0
Within Powerhouse Capacity and > 10,000*	0.25 to 0.5
Within Powerhouse Capacity and <= 10,000*	0.25 or less

* Maximum fall rate schedule is suspended in Composite Zone 4
** Consistent with safety requirements, flood control purposes, and equipment capabilities.
*** For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control down ramping rate. Therefore, no ramping rate is required.

Drought operation definition in the recommended plan is the same as NO-Action except the drought plan is "triggered" when composite storage falls below the bottom of Zone 2 into Zone 3 as shown in Figure 19. Note that composite storages are defined based on Revised Action Zones.

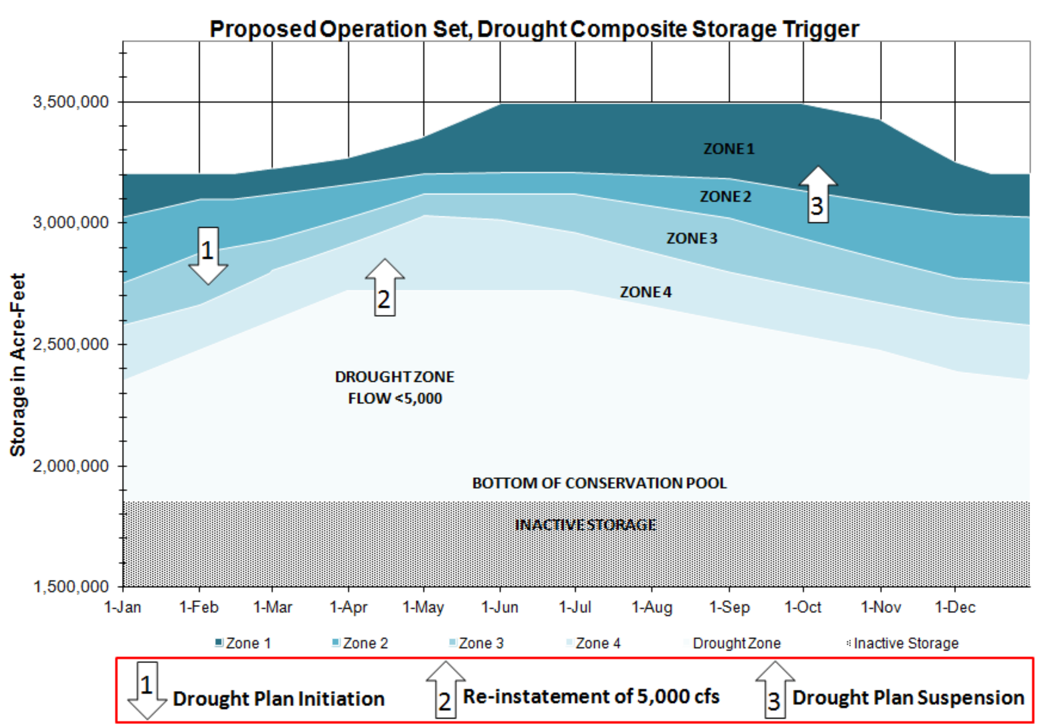

Figure 19. Modified RIOP Composite Storage Triggers

3. Hydroelectric Power Generation

The Corps will continue to operate Buford Dam, West Point Dam, Walter F. George Dam, and Jim Woodruff Dam for hydropower generation, as described in the NOAction Alternative. The proposed alternative does not result in changes to hydropower generation operations at West Point Dam, Walter F. George Lock and Dam or Jim Woodruff Lock and Dam, except as might result from changes in the action zones.

A reduction of generation under drought protocols was implemented under the proposed alternative. Revisions are applied in all zones as shown in Table 11. During drought operations generation would typically be reduced to that depicted in Table 11.

Table 11. Buford Dam Hydropower Generation Schedule

Action Zones	NOAction Alternative Generation (hrs)	Proposed Alternative Generation	
		Non-Drought (hrs)	Drought Ops (hrs)
Flood Control	3	3	2
Zone 1	3	3	2
Zone 2	2	2	1
Zone 3	2	2	1
Zone 4	0	0	0

4. Navigation

The provision of reliable navigation has always been a challenging task in the ACF System. A Navigation measure considered was the concept of a definite navigation season (January through May). In developing this measure, the Corps balanced use of storage for navigation versus the use of storage for other authorized project purposes and considered the effects on other needs and requirements in the system such as hydroelectric power generation and recreation. Assessment of the frequency of channel availability and the number of drought operations triggered by the implementation of navigation showed that navigation options are only feasible when the composite system storage is in Zones 1 or 2. Figure 20 shows the conservation storage in a navigation season.

The goal of the navigation operation rules is to maintain a flow rate of 16,200 cfs at Blountstown as much as possible, which represents 7 ft of minimum navigation depth.

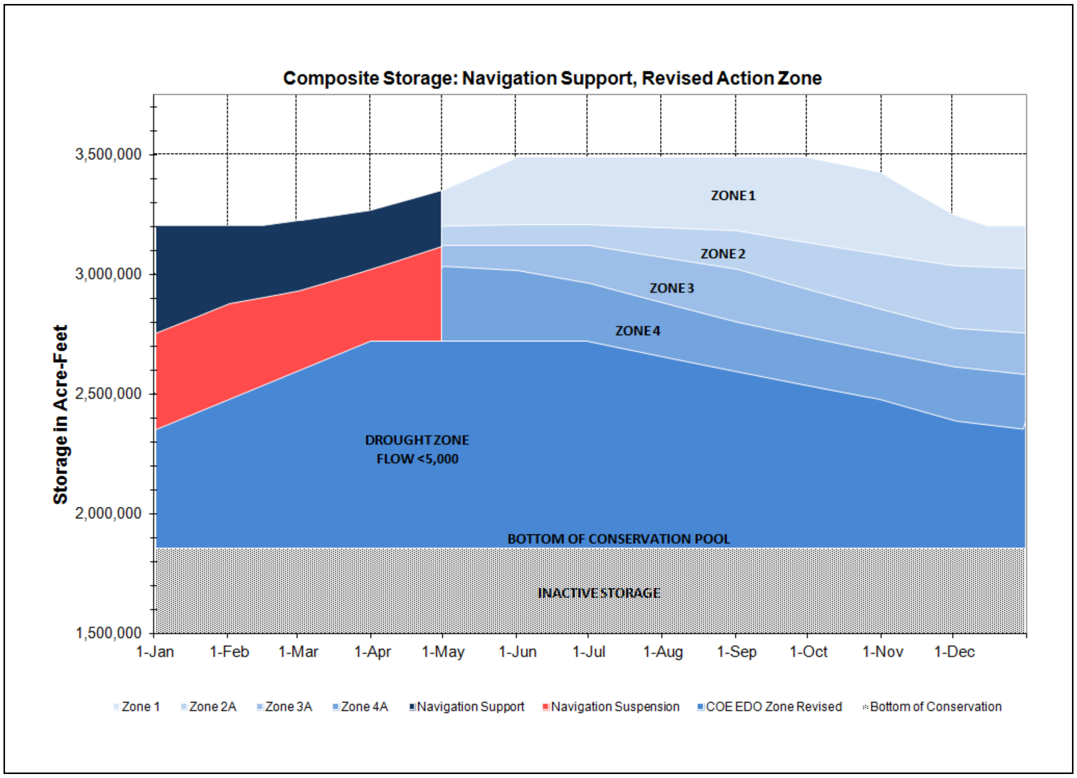

Figure 20. Conservation Storage in a Navigation Season (Jan-May)

Nested conditional statements use existing RIOP state variables as well as one named *NavigationSeason*, which indicates whether the release decision occurs during January-May. If true, and if the system composite storage zone is 1 or 2 and not under drought operations then the minimum release rule *MinRel_Navigation* specifies release. The settings are shown in Figure 21 and Figure 22. Description of the state variables can be found in Appendix H.

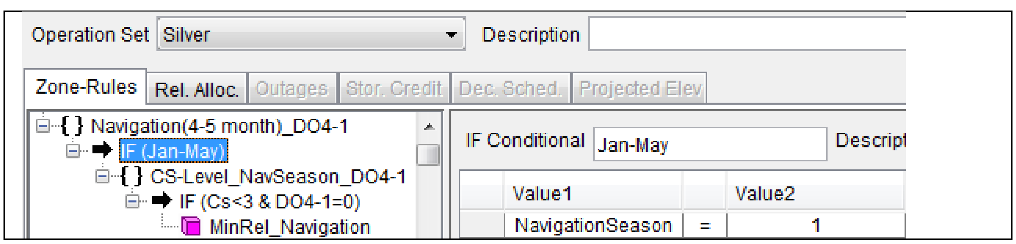

Figure 21. Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

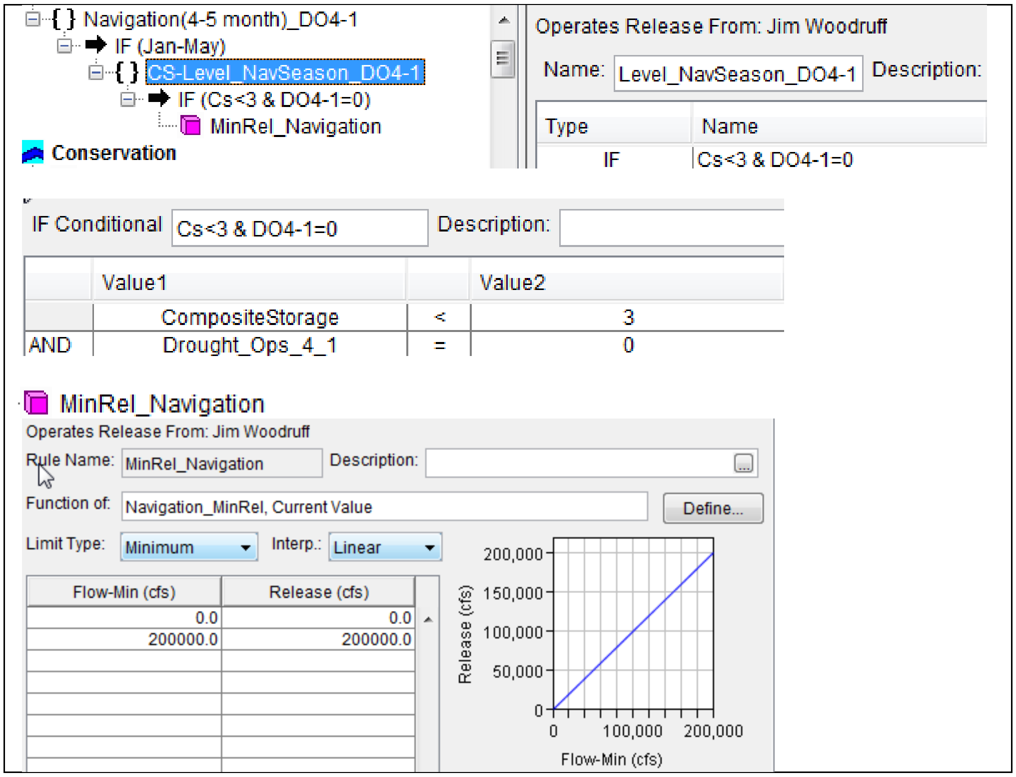

Figure 22. Release Rules for *Navigation(4-5month)_DO4-1* Rule

5. Prolonged low flow

The Prolonged Low Flow criteria, suspend maximum fall rates when flows have been < 7,000 cfs for 30 days, and resume when flows > 10,000 cfs for 30 days. The state variable *ProlongedLowFlow* shown in Figure23 described in Appendix H. If flow conditions are met and the state variable equals 1, then *BI-Falling Ramp Rate* rule is used instead of *RIOP-Falling Ramp Rate PA2*.

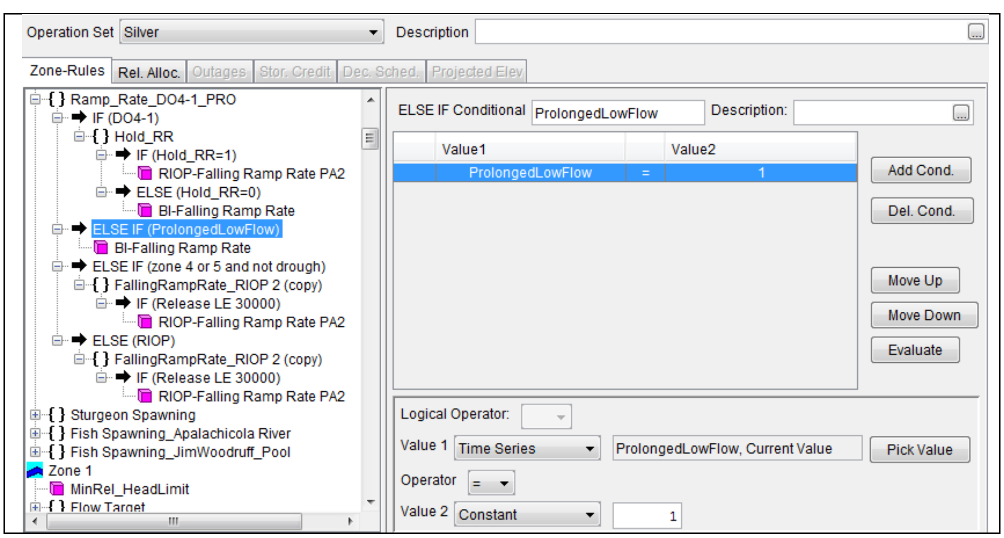

Figure 23. Conditional Block for *Ramp_Rate_DO4-1_PRO* Rule

6. Water Supply

Water supply management for the recommended plan is the same as NOAction. The PDT defined eight different water supply options shown in Figure 24. Based on these options, fifteen different alternatives have been created in the model which are shown in Table 12. More details are explained in section X of Appendix K.

Alternative					Net Water Supply Consumption Upstream of Buford Dam (mgd)									Net Water Supply Consumption at Atlanta (Chattahoochee River Below Buford Dam)		
Description	Total Water Supply Withdrawal Upstream of Buford and Downstream at Atlanta	Lanier Withdrawals (Gross)			Total Withdrawals Upstream of Buford Dam				Total Returns Upstream of Buford Dam[1]				Upstream Net Withdrawals	River Withdrawals	River Returns	River Net Withdrawals
		Relocation	'56 Act*	WSA*	**Upper Chattahoochee Withdrawals	Glades Withdrawal	Lanier Withdrawals	Subtotal	**Upper Chattahoochee Returns	Glades Returns	Lanier Returns	Subtotal				
A - NEPA No Action	412.5 (135.5+277)	20	10	98	7.5	0	128	**135.5**	1	0	37 29 %	**38**	**97.5**	277	227 (82 %)	50
B – No WSA or '56	304.5 (27.5+277)	20	0	0	7.5	0	20	**27.5**	1	0	10 50%	**11**	**16.5**	277	227 (82 %)	50
C - Future Without W/Glades pumping	475.5 (67.5+408)	20	0	0	7.5	40	20	**67.5**	1	22 55%	10 50%	**33**	**34.5**	408	335 (82 %)	73
D - GA 2013	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	163 55%	**164**	**140.5**	408	384 (94 %)	24
E – GA 2013 w/Glades pumping	712.5 (304.5+408)	20	10	227	7.5	40	257	**304.5**	1	22 55%	141 55%	**164**	**140.5**	408	384 (94 %)	24
F - GA 2013 Current Returns	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	91 30.6%	**92**	**212.5**	408	335 (82 %)	73
G - GA 2013 Max Treatment Facility Capacity	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	128 43%	**129**	**175.5**	408	477 (117 %)	69***
H - 2066	680.5 (272.5+408)	*20*	*10*	*155*	*7.5*	*40*	*185*	***232.5***	*1*	*16 40.4%*	*75 40.4%*	***92***	***140.5***	*408*	*384* (94 %)	*24*

[1]For purposes of this table, "returns" are defined as treated wastewater discharges by the entities that withdraw water for municipal and industrial use upstream of Buford Dam or from the Chattahoochee River at Atlanta. Because these returns vary in relation to the amount of water supply withdrawals evaluated under the different alternatives, it is necessary to estimate and consider the varying amounts of returns along with withdrawals for each alternative.

*Volumes in the columns titled WSA and '56 Act reflect withdrawals that could be accommodated under the Water Supply Act or the 1956 Act . For the NEPA No Action (Water Supply Option A) numbers have been entered to reflect withdrawals that are currently occurring; however, no WSA or '56 Act agreements have been entered into.

**The Upper Chattahoochee withdrawal and returns above Buford are based on year 2007 actual water use.

***Refers to a net gain in river volume due to returns in excess of 100%

River returns were updated to 2012 as a result of new information provided by GA EPD.

Note that although the 257 option appears "intermediate" when compared to 297, alternatives D and E are identical in terms of total water supply use. That is not a problem, just an observation.

Option E: This water supply option developed to reflect 40 mgd being provided by Glades (i.e., Glades is a partial supplier of H2O)

We need to insert some return figures here, because otherwise it is not apparent why these alternatives wouldn't be reasonable. (I believe they would exceed available storage, but assuming returns could be increased enough they would not, correct?)

Future without w/Glades pumping: Assumes no further action under WSA/'56 Act, but releases will be made to accommodate downstream water supply withdrawals.

GA 2013 – Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will not undergo full impacts analysis because the volumes represented in this water supply option are 'bracketed' (i.e., are between) values in other water supply options that will undergo full analysis. It is reasonable to assume that impacts from GA 2013 - Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will be reflected in analysis conducted for other options.

No Action Lanier returns are drawn from year 2012. Gwinnett County's Wayne Hill treatment facility became action in 2010, resulting in increased return rates. Source of new volumes is GA EPD, provided in response to SAM request for the most current data.

No Action Lanier withdrawals are drawn from year 2007 because 2007 was the year of greatest net water use in the ACF basin.

Figure 24. Water Supply Withdrawal Options

Table 12. Combination of alternatives and water supply options

No.	Alternative Name	Alternative	Water Supply Option
1	NOActionAx	NO_Action	A
2	Alt1_OptBx	Alt1	B
3	Alt1_OptCx	Alt1	C
4	Alt2_OptBx	Alt2	B
5	Alt3_OptBx	Alt3	B
6	Alt4_OptBx	Alt4	B
7	Alt5_OptBx	Alt5	B
8	Alt6_OptBx	Alt6	B
9	Alt7_OptAx	Alt7	A
10	Alt7_OptBx	Alt7	B
11	Alt7_OptCx	Alt7	C
12	Alt7_OptDx	Alt7	D
13	Alt7_OptEx	Alt7	E
14	Alt7_OptFx	Alt7	F
15	Alt7_OptHx	Alt7	H

C. Study Alternatives/Operational Plans

The operation measures described above were investigated, revised, and combined to achieve an improved operation of the system with respect to the following objectives .

- Define action zones on a scientific basis which eliminate disproportionate impact on reservoirs and address current system needs.
- Reduce or eliminate the chances of prematurely returning to drought operations and reducing flows downstream of Jim Woodruff Dam to less than 5,000 cfs.
- Reduce or eliminate the adverse effect of reservoir regulation on endangered species.
- Improve system performance to achieve congressionally authorized project purposes.
- Increase the reliability of navigation on the ACF System.

Table 13 presents the basin-wide water management alternatives developed to meet the study objectives and ensure that authorized purposes would not be compromised. Alternatives were developed by adding one operational measure at a time, determining the operation for that measure that best satisfies the objectives, and then developing another alternative by adding another measure. Intermediate alternatives built one upon another ultimately established the recommended plan for water management in the ACF Basin.

Table 13. Summary of Alternative Management Measures

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

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

The sections that follow further detail each alternative and describe the rationale for which alternatives were carried forward for detailed impacts analysis.

1. NOAction Alternative

The NOAction alternative includes current operations and incorporates support for water supply as mandated by the 2012 Federal Court ruling. This is represented with a) an 800 cfs minimum flow target at Peach Tree Creek (Atlanta) to support the water quality objective there and account for the water supply withdrawals taken from the river and b) the lake withdraws are represented at the inflow to Buford and reflect the 2007 withdrawal levels. This alternative uses the action zones defined in the draft 1989 ACF WCM, current hydroelectric power generation schedules, and current fish and wildlife conservation practices such as spawning SOP, and the RIOP for releases from Jim Woodruff Lock and Dam.

2. Alternative 1

Alternative 1 is a copy of the NOAction alternative except that the two proposed reservoirs, Glades and Bear Creek were added to the network.

3. Alternative 2

Alternative 2 was created as a copy of Alternative 1, but adds the management measures of revised action zones, modified hydroelectric power generation schedules, 4/5 month navigation, and seasonal minimum flow at Peach Tree Creek.

4. Alternative 3

Alternative 3 started as a copy of Alternative 2 but replaced the 4/5 month navigation with the Tri-Rivers navigation measure.

5. Alternative 4

Alternative 4 started as a copy of Alternative 2 but replaces the current Basin Inflow computations with the Florida Basin Inflow computations and replaces the current RIOP and ramping rates with the, Florida Flow Target and Florida ramping rate measures.

6. Alternative 5

Alternative 5 started as a copy of Alternative 2 but replaces the current Basin Inflow computations with the Georgia Basin Inflow computations and replaces the current RIOP with the Georgia Flow Target. It also suspends the ramping rate after pulse flows.

7. Alternative 6

Alternative 6 started as a copy of Alternative 2 but replaces the current RIOP with the FWS Flow Target, replaces the seasonal Peach Tree Creek objectives with a monthly -varying minimum, and resets the drought operation suspension zone from zone 1 to zone 3.

8. Alternative 7

Alternative 7 started as a copy of Alternative 2 but changed the drought operation trigger zone from zone 4 to zone 3.

9. Recommended Alternative

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

V. Results of Modeling

Each simulated alternative produces daily results including reservoir releases (both total and per outlet), 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 25 shows the list of custom scripts used for plotting and building reports.

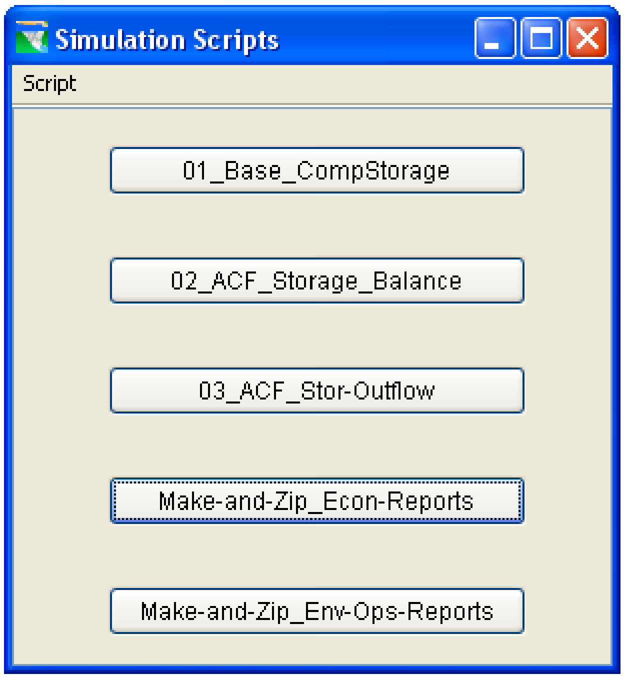

Figure 25. Simulation Scripts for Generating Plots and Reports

The "Base Composite Storage" plot (Figure 26) includes curves of the computed daily storages for Buford, West Point, and Walter F. George along with curves indicating the Drought state and system zone.

The "Storage Balance" plot (Figure 27) shows a relative percentage comparison of how the conservation storage balances for the three projects (Buford, West Point, and Walter. F. George) are working as a tandem system for Jim Woodruff (so minimum releases can be made from Jim Woodruff for a variety of purposes).

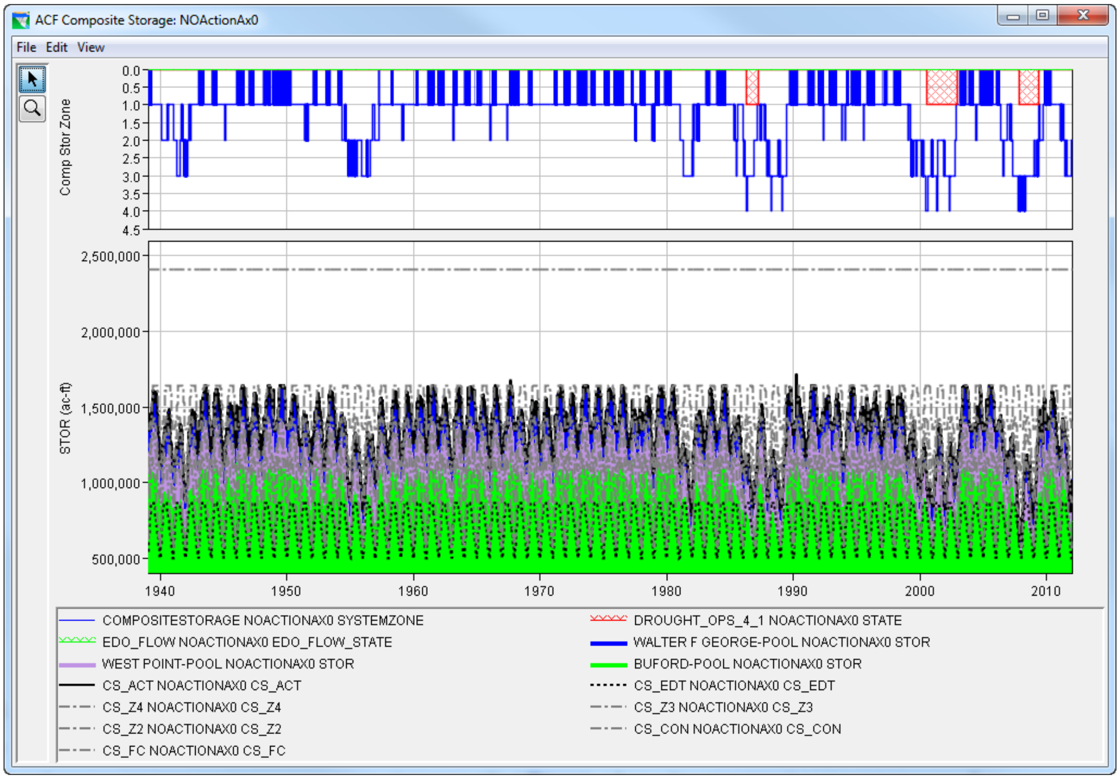

Figure 26. Scripted Plot: Base Composite Storage (POR Simulation, NO-Action Operations)

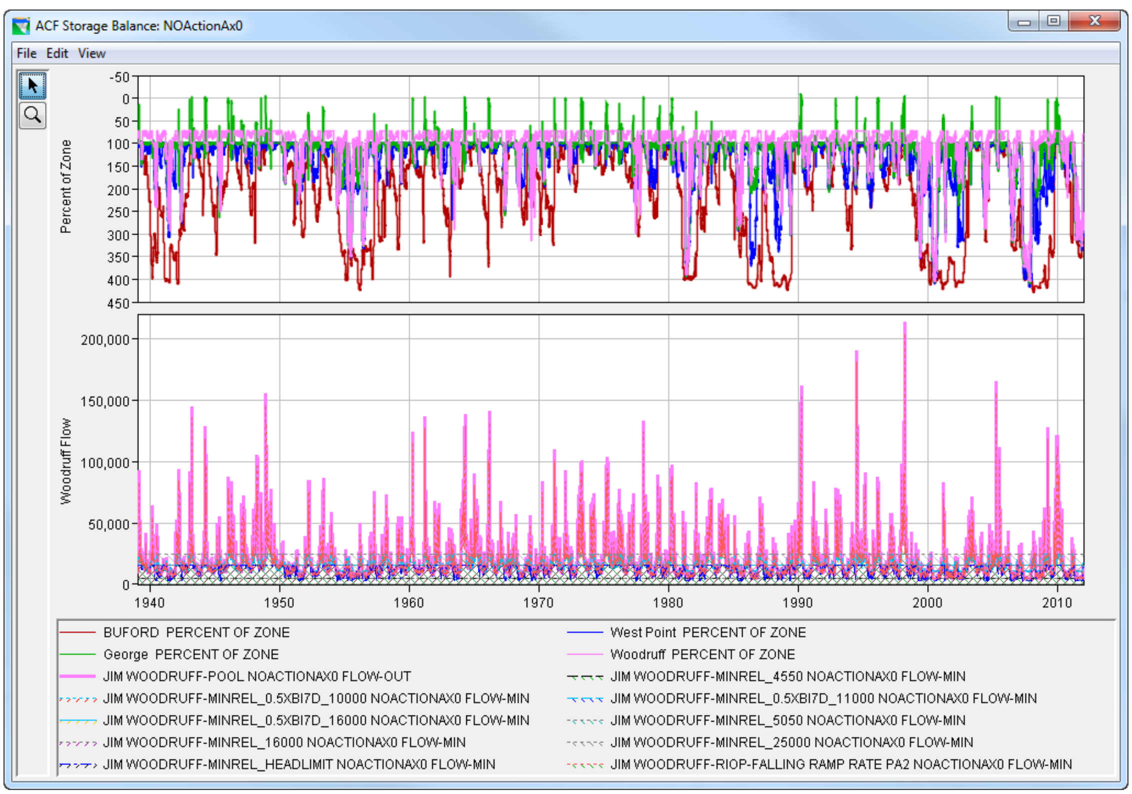

Figure 27. Scripted Plot: Storage Balance (POR Simulation, NO-Action Operations)

The “Storage Outflow” plot (Figure 28) shows zones and computed storages for the system reservoirs, as well as the outflow from the system (releases from Jim Woodruff).

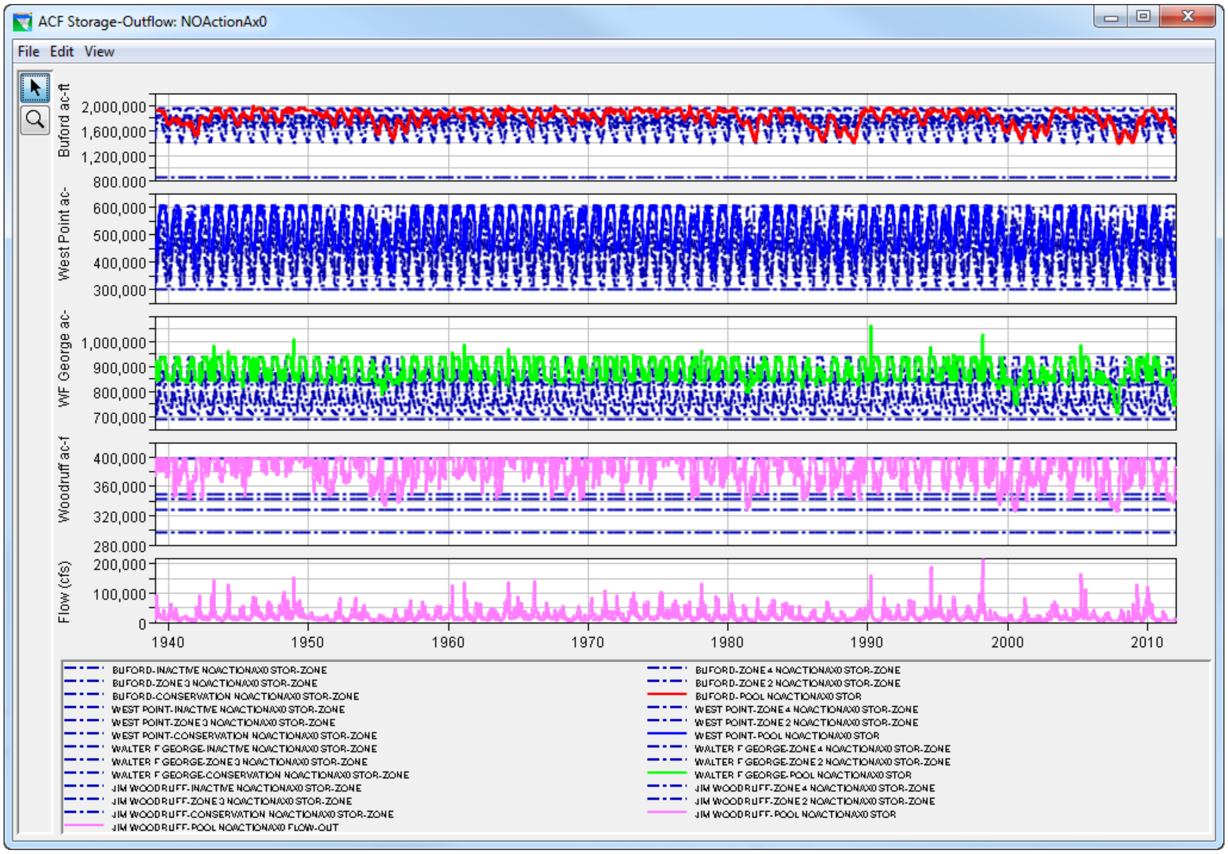

Figure 28. Scripted Plot: Storage Outflow (POR Simulation, NO-Action Operations)

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Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

List of Appendices

June 2014

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Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix A – Buford (Lake Lanier)

June 2014

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Appendix A – Buford

Table of Contents:

List of Tables:

List of Figures:

Buford (Lake Sidney Lanier)

I. Overview

Lake Sidney Lanier is formed by Buford Dam, which is located about 48 miles northeast of Atlanta on the Chattahoochee River. The Mobile District of the Corps of Engineers operates the project for multipurpose uses such as flood damage reduction, hydroelectric power generation, and navigation. In operating for these purposes, the project regulates downstream flows, providing incidental benefits such as water supply for the city of Atlanta and water quality flows for the maintenance of the 750- cfs minimum in-stream flow at Peachtree Creek. Buford Dam releases are further regulated by the downstream project Morgan Falls operated by Georgia Power Company.

Figure A.01 shows the location of Buford Dam and its pool (Lake Sidney Lanier) as it is represented in the HEC-ResSim model, and Figure A.02 shows a photo of Buford Dam.

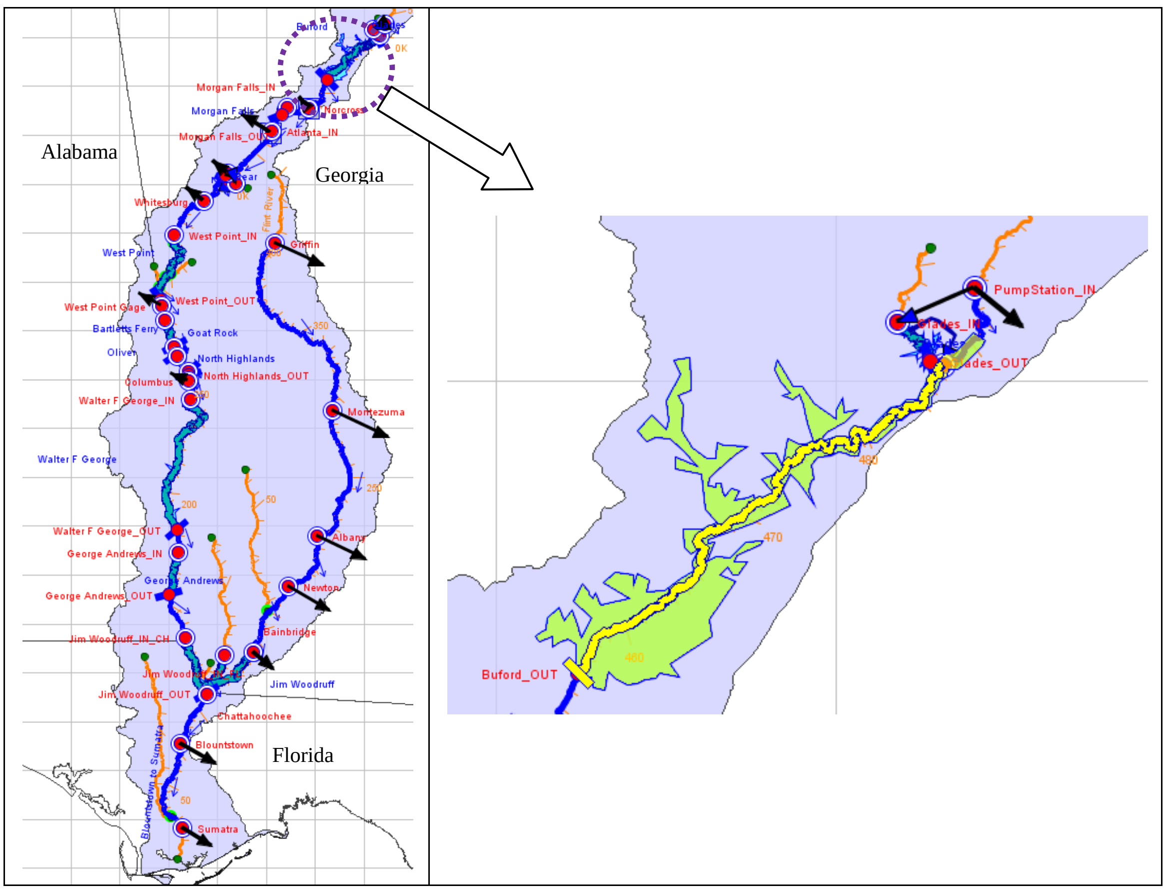


Figure A.01 HEC-ResSim Map Display Showing Location of Buford

Figure A.02 Photo of Buford Dam

II. Physical Characteristics

The project consists of a rolled-earth dam 1,630 feet long with crest at elevation 1,106 ft National Geodetic Vertical Datum of 1929 (NGVD), which is about 192 ft above streambed elevation; three earthen saddle dikes with a total length of 5,406 ft; a chute spillway with crest at elevation 1,085 ft; a powerhouse in a deep cut, with steel penstocks in tunnels and a concrete intake structure at the upstream end of the tunnels; and a flood-control sluice tunnel paralleling the power tunnels.

Lake Lanier has a storage capacity (at the top of conservation pool - elevation 1,070 ft) of 1,917,000 ac- ft. Of that, 1,049,400 ac- ft is conservation storage and 867,600 ac- ft is inactive storage. The minimum conservation pool elevation is 1,035 ft, and the maximum conservation pool elevations are 1,071 ft in the summer and 1,070 ft in the winter. In addition, 637,000 ac- ft is reserved for flood storage between elevations of 1,085 and 1,070 ft. Lake Lanier has a surface area of 38,542 acres at an elevation of 1,071 ft. The power installations consist of one 7-megawatt (MW) generating unit and two units of 60 MW each, for a total of 127 MW. The penstock capacity is 12,000 cfs. The project is typically operated for peaking power on the weekday, with Saturday and Sunday off. The number of hours of generation per day depends on the available storage, conditions in the basin, and electrical demand. The 7-MW unit runs continuously (at 600 cfs) to help meet downstream minimum flow requirements.

Buford's headwater location at the upstream end of the ACF watershed makes its storage very useful during dry times. On the other hand, the relatively small upstream drainage area and the magnitude of annual precipitation in that area make the project difficult to refill.

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the HEC-ResSim model. The *elevation-storage-area* defines the pool as shown in Figure A.03. The dam consists of four types of outlets: (1) an uncontrolled spillway, (2) a flood control sluice, (3) a small unit, and (4) a power plant. Each of these outlets is defined in the model as shown in Figure A.04, and the Dam reflects the composite release capacity of all of the outlets.

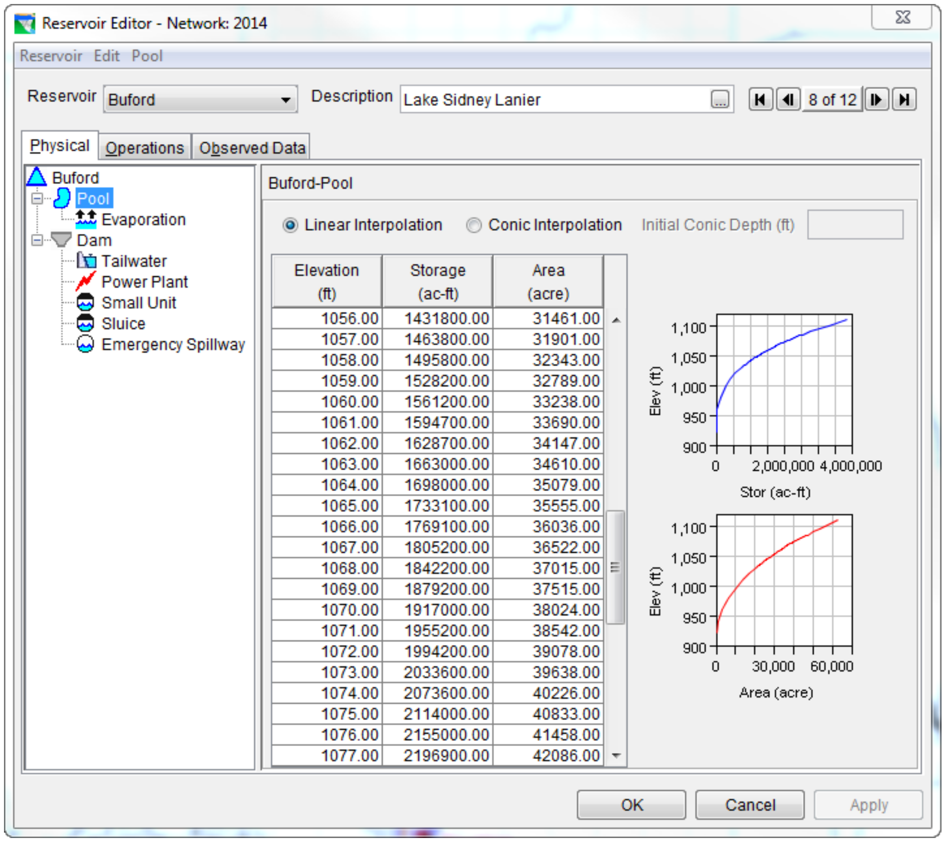


Figure A.03 Reservoir Editor – Network 2014 : Physical Tab -- Pool

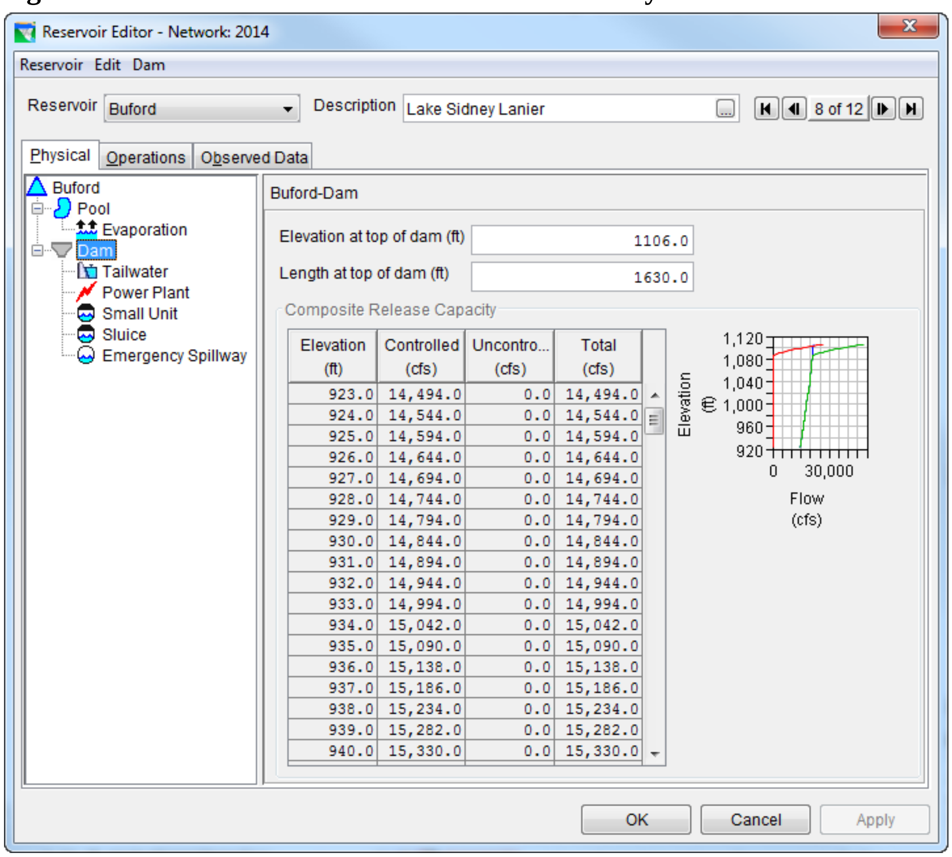


Figure A.04 Reservoir Editor – Network 2014: Physical Tab -- Dam

III. NOAction Operations

Buford Dam is designed to impound a large amount of storage, and officially operates for flood control, hydropower, and navigation.

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 Buford's "NO-Action" operational zones, which consist of zones of flood control and conservation (divided into intermediate zones), as well as an operating inactive zone. These zones contain a set of operational rules for reservoir operation while the Top of Dam and Inactive zones define the boundary elevations for those zones.

Table A.01 Zone Elevations for "NO-Action" Operation Set

Buford	NO-Action Top of Zone Elevation Values (feet) Blue values = entered; Black *italic* values = assumed; Orange linear = linear-interpolated values							
Seasons =	**1-Jan**	**1-Feb**	**1-Mar**	**15-Apr**	**1-May**	**30-Jun**	**30-Sep**	**1-Dec**
Zones:								
Top of Dam	1106	*1106*	*1106*	*1106*	*1106*	*1106*	*1106*	*1106*
Flood Control	1085	*1085*	*1085*	*1085*	*1085*	*1085*	*1085*	*1085*
Conservation	1070	*1070*	*1070*	1070	1071	*1071*	1071	1070
Zone 2	1065	1068	*1068*	*1068*	*1068*	1068	1066.5	linear
Zone 3	1062	1067	*1067*	*1067*	*1067*	1067	1064.5	linear
Zone 4	1055	linear	1065	*1065*	*1065*	1065	linear	1056
Operating Inactive	1035	*1035*	*1035*	*1035*	*1035*	*1035*	*1035*	*1035*
Inactive	919	*919*	*919*	*919*	*919*	*919*	*919*	*919*

The top of the operation zones vary seasonally (as shown in Figure A.05). These zones are used in balancing the system through tandem operations to meet the ESA release requirements from Jim Woodruff. They are also used to define the composite action zones and track the active composite zone to determine flow releases together with basin inflow and operating seasons in accordance with the requirements in RIOP 2012.

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

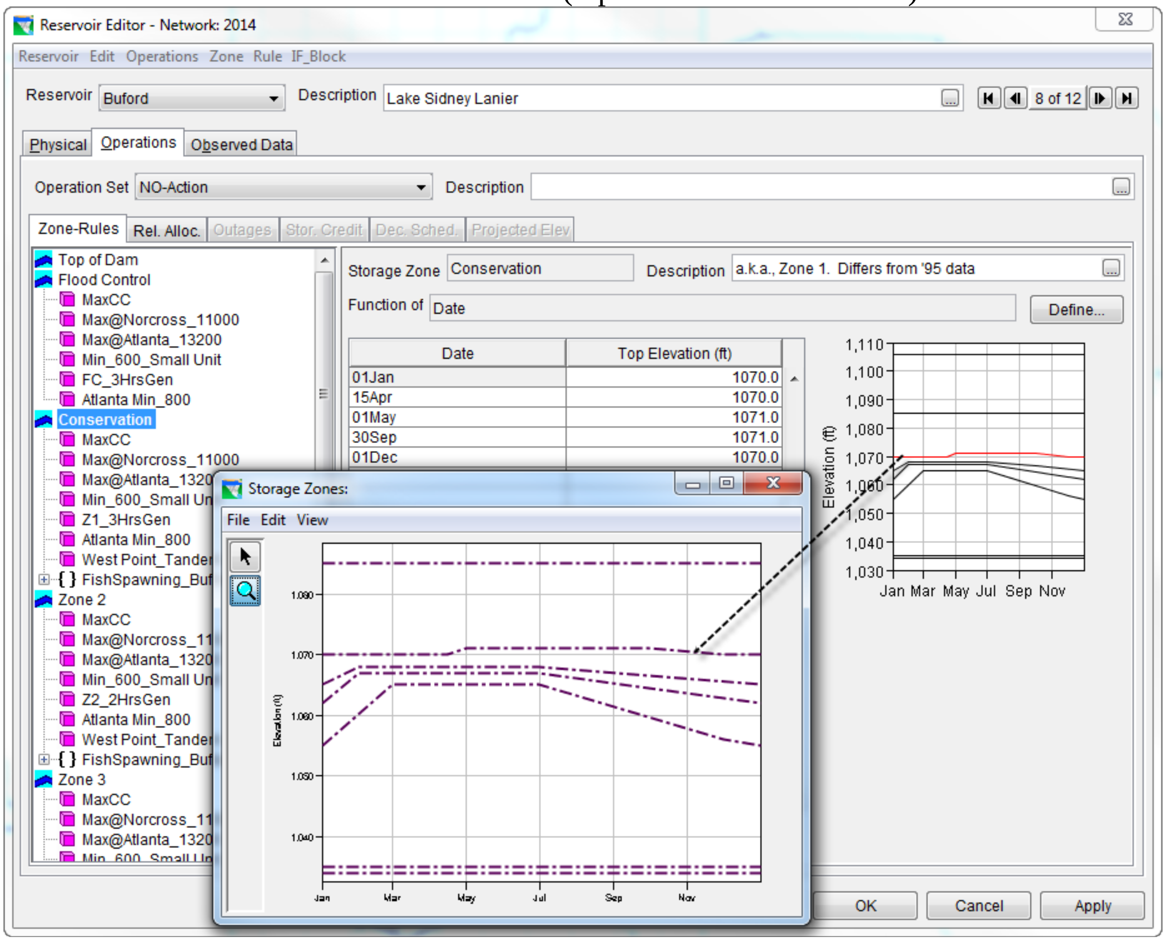


Figure A.05 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

Figure A.06 shows a sequential release allocation approach specified for available outlets along Buford 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 flood control sluice.

Release Allocation:

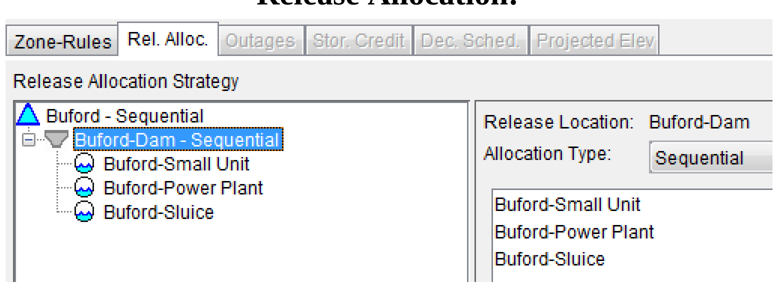


Figure A.06 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

Figure A.07 shows a set of operational rules specified for each zone that reflects the operation set named *NO-Action*.

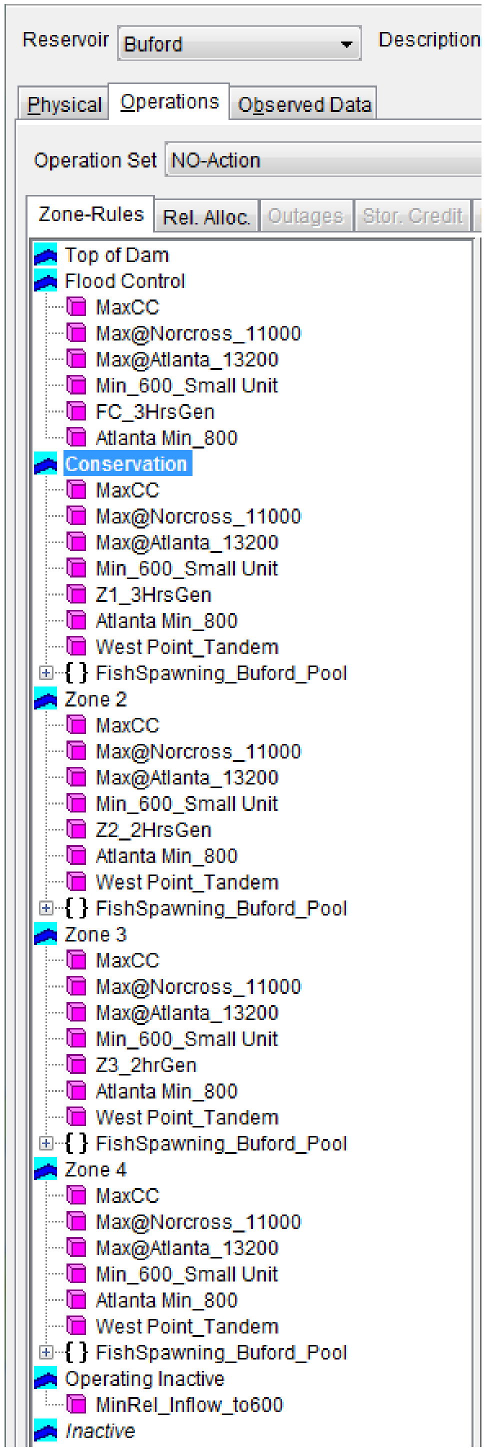


Figure A.07 Reservoir Editor – Network 2014: Operations Tab– NO-Action OpSet – Zones and Rules

The content for each of these rules in the HEC-ResSim model are shown in Figure A.08 through Figure A.13. The logic and purpose for each operational rule is described in Section C.

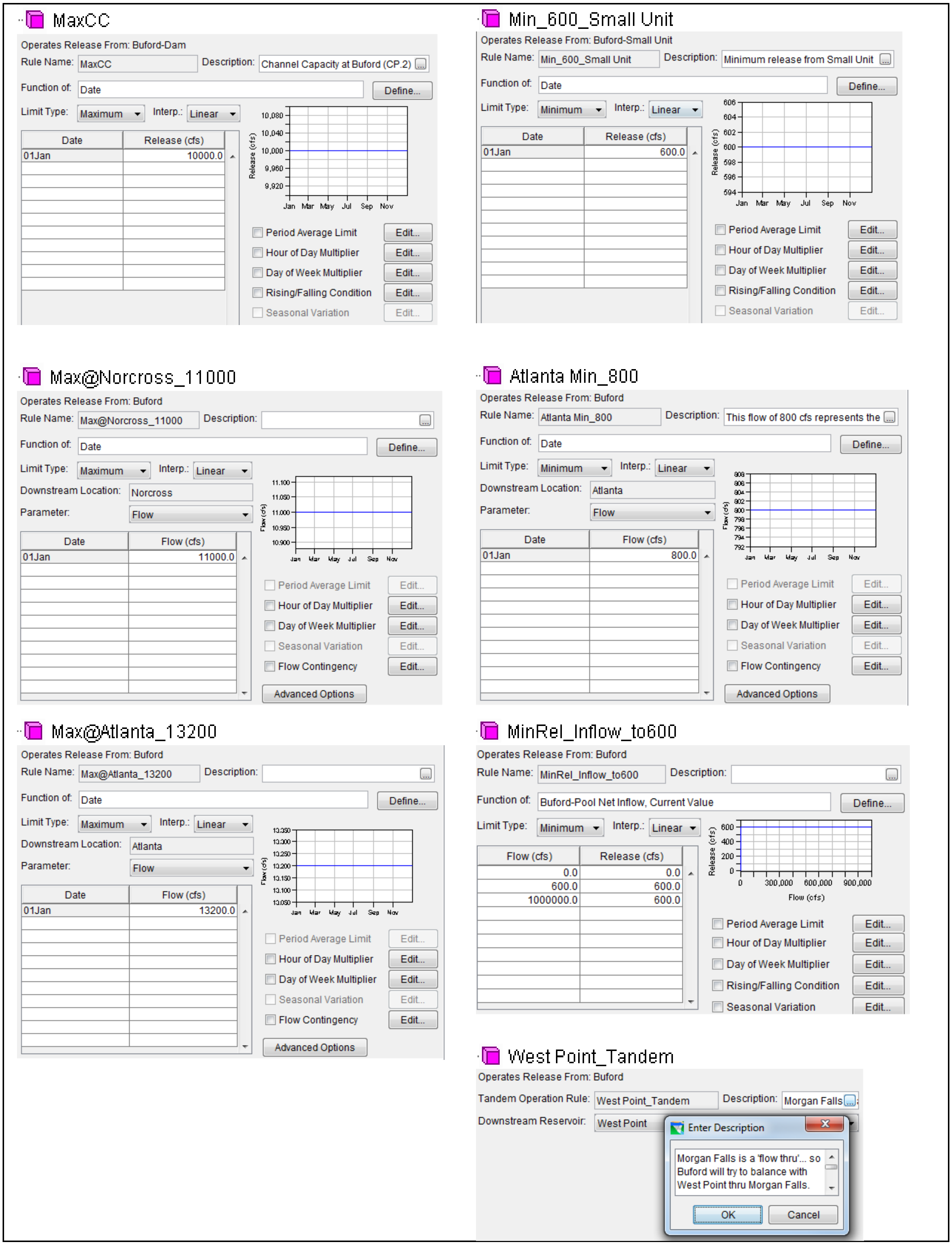
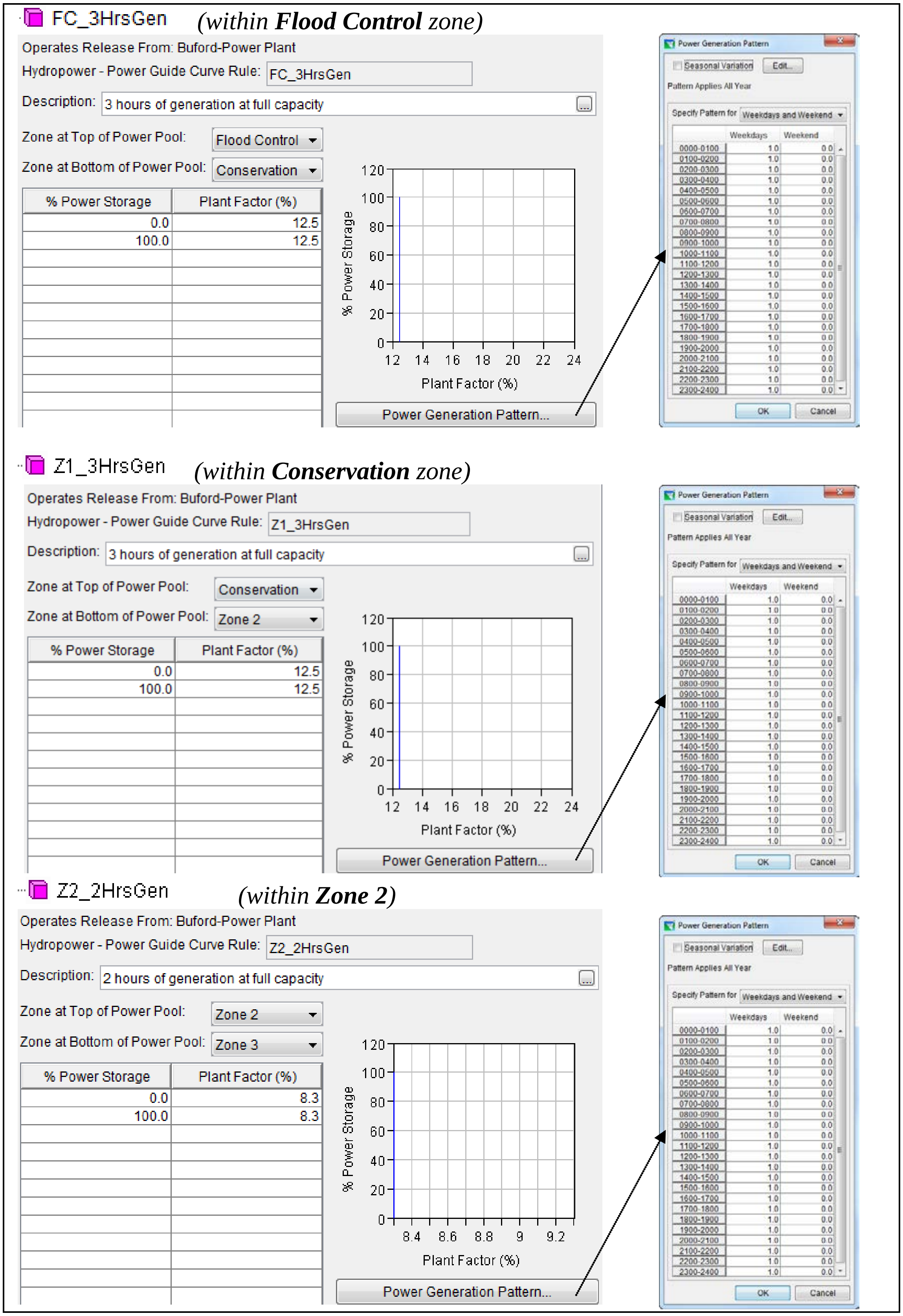


Figure A.08 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Max, Min, and Tandem Rules



FC_3HrsGen
(within Flood Control zone)
Operates Release From: Buford-Power Plant
Hydropower - Power Guide Curve Rule: FC_3HrsGen
Description: 3 hours of generation at full capacity
Zone at Top of Power Pool: Flood Control
Zone at Bottom of Power Pool: Conservation
% Power Storage | Plant Factor (%)
0.0 | 12.5
100.0 | 12.5
% Power Storage
Plant Factor (%)
Power Generation Pattern...
Power Generation Pattern
Seasonal Variation
Edit...
Pattern Applies All Year
Specify Pattern for
Weekdays and Weekend
Weekdays
Weekend
OK
Cancel
Z1_3HrsGen
(within Conservation zone)
Operates Release From: Buford-Power Plant
Hydropower - Power Guide Curve Rule: Z1_3HrsGen
Description: 3 hours of generation at full capacity
Zone at Top of Power Pool: Conservation
Zone at Bottom of Power Pool: Zone 2
% Power Storage | Plant Factor (%)
0.0 | 12.5
100.0 | 12.5
Z2_2HrsGen
(within Zone 2)
Operates Release From: Buford-Power Plant
Hydropower - Power Guide Curve Rule: Z2_2HrsGen
Description: 2 hours of generation at full capacity
Zone at Top of Power Pool: Zone 2
Zone at Bottom of Power Pool: Zone 3
% Power Storage | Plant Factor (%)
0.0 | 8.3
100.0 | 8.3

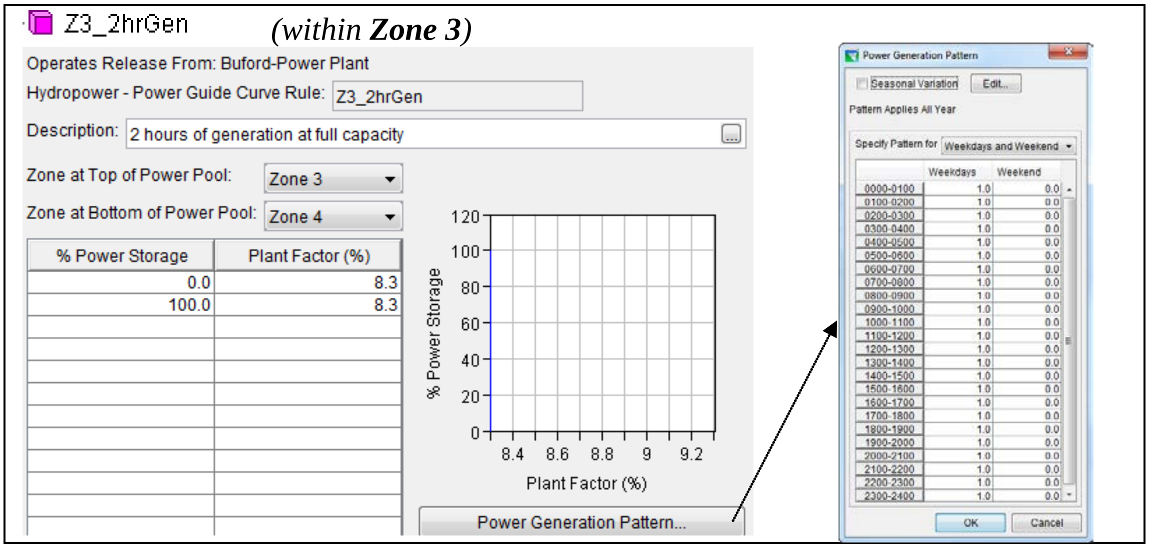


Figure A.09 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Hydropower Rules

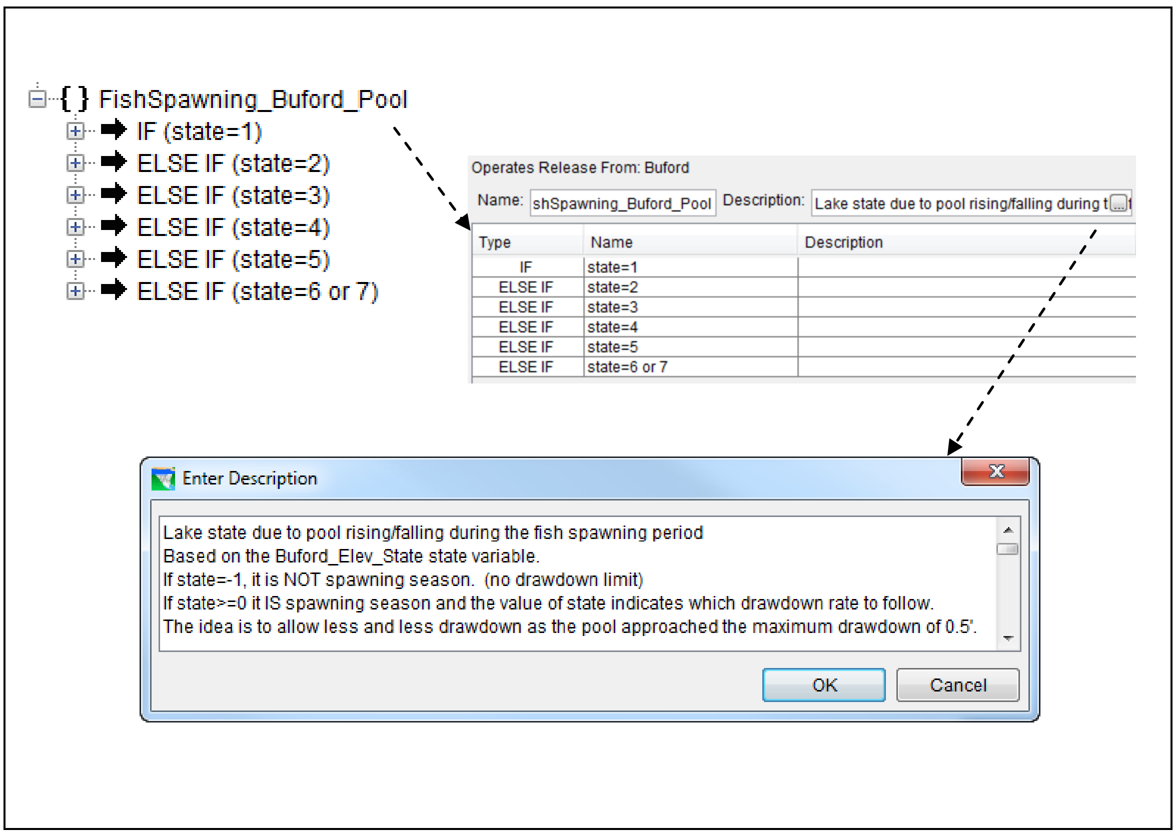


Figure A.10 Fish Spawning -- "Conditional Blocks"

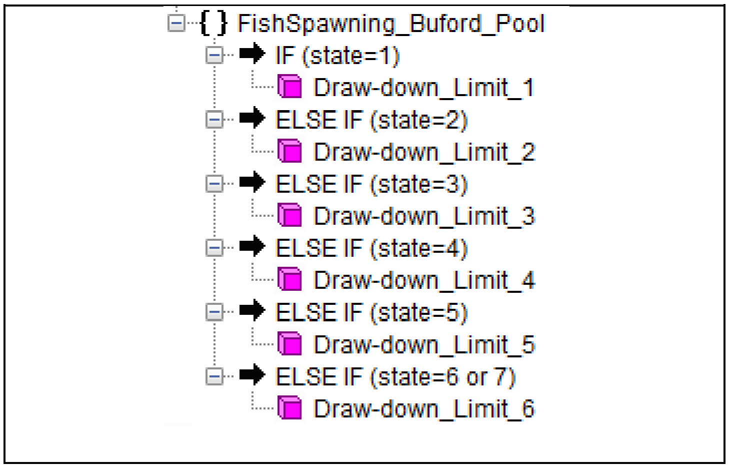


Figure A.11 Fish Spawning -- "IF-Blocks" and "Rules"

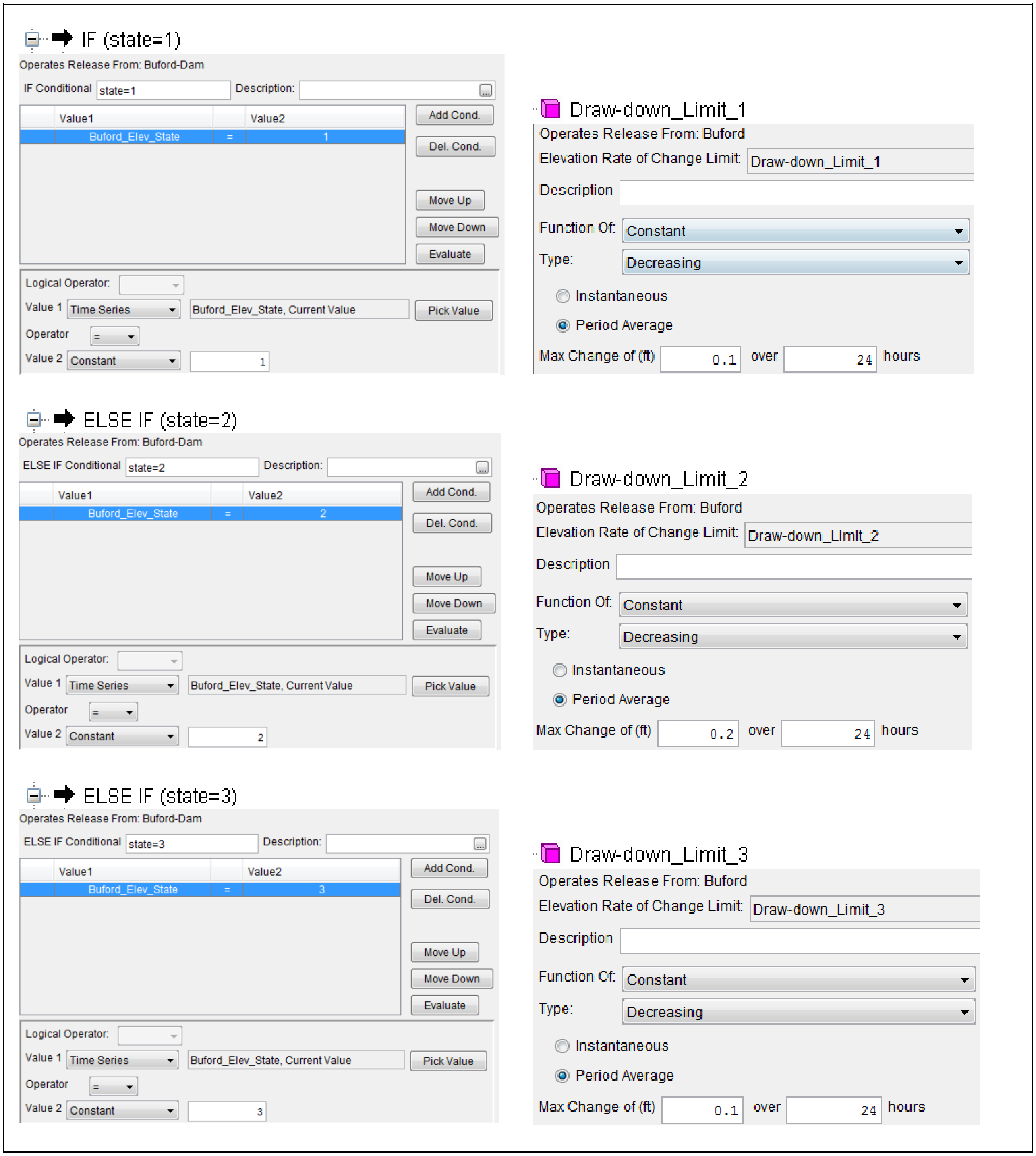


Figure A.12 Fish Spawning – Rules for "Buford_Elev_State" Values (Part 1 of 2)

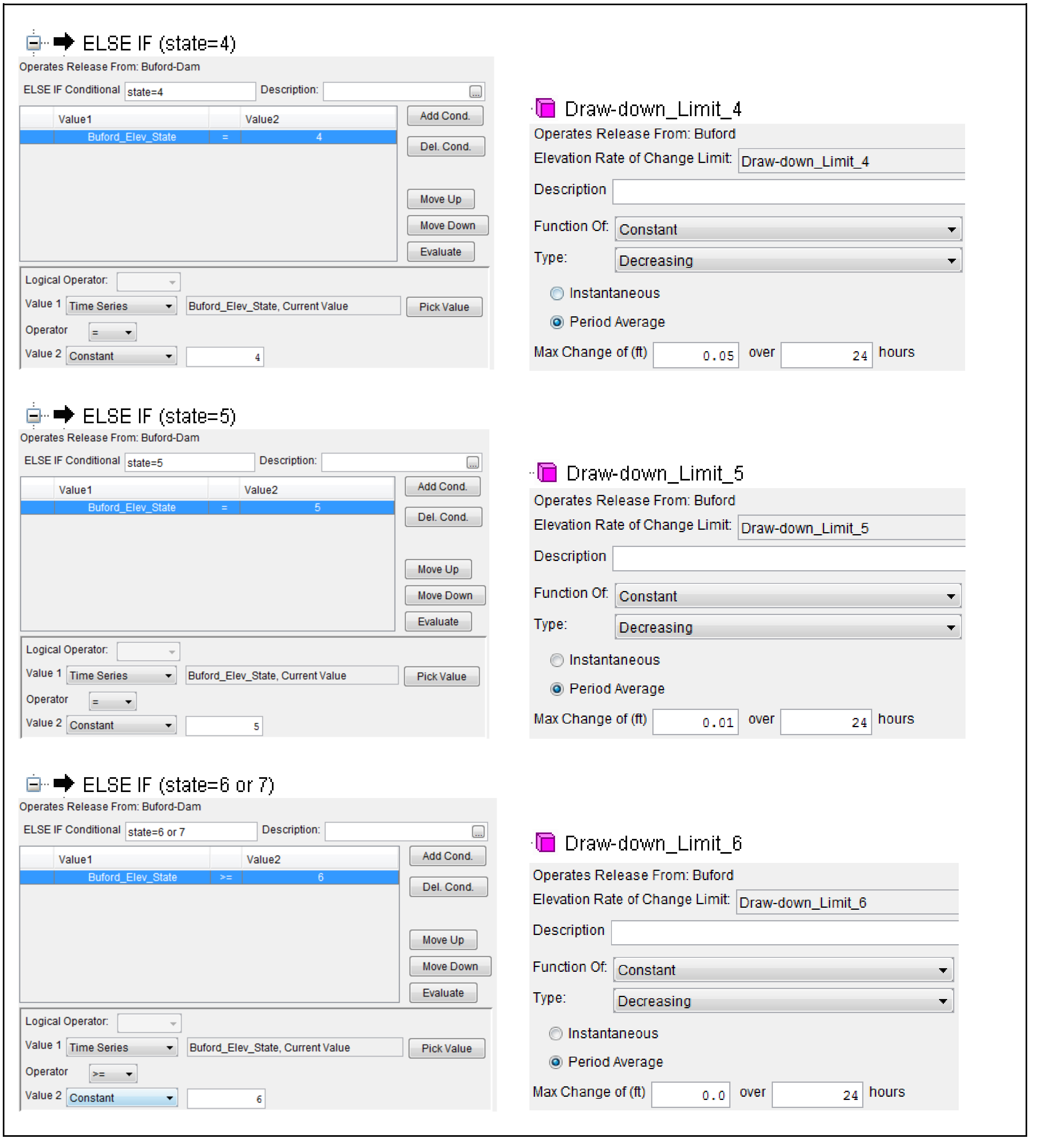


Figure A.13 Fish Spawning – Rules for "Buford_Elev_State" Values (Part 2 of 2)

C. Rule Descriptions

1. MaxCC

This rule (see Figure A.08) sets a maximum release from Buford Dam to meet the channel capacity (10,000 cfs) for the Chattahoochee River just downstream of Buford Dam at Gage No. 02334430.

2. Max@Norcross_11000

This rule (see Figure A.08) is a downstream control rule. It sets the channel capacity (11,000 cfs) for the Chattahoochee River at the Norcross streamflow gage location. A downstream maximum flow rule determines the release from the dam such that the sum of the reservoir release and all local inflows between the dam and the downstream control location does not exceed the specified maximum flow.

3. Max@Atlanta_13200

This rule (see Figure A.08) is a downstream control rule. It sets the channel capacity (13,200 cfs) for the Chattahoochee River at Atlanta streamflow gage location.

4. Min_600_Small Unit

This rule (see Figure A.08) represents the flow release from the small unit, which is in use continuously throughout the year. Once the unit is on, the flow release is at approximately a constant of 600 cfs.

5. Atlanta Min_800

This rule (see Figure A.08) is to provide a minimum water quality flow of 750 cfs in the Chattahoochee just upstream from the junction with Peachtree Creek. The model uses 800 cfs to add a factor of safety to guarantee the minimum flow.

6. MinRel_Inflow_to600

This rule (see Figure A.08) represents the release relationship between inflow to Lake Lanier and dam releases in the Operating Inactive zone. The rule sets the minimum release from Buford equal to the inflow for inflow values up to 600 cfs. For inflow values above 600 cfs, the minimum release remains at 600 cfs.

7. West Point_Tandem

This rule (see Figure A.08) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F George, and Lake Seminole to meet the Endangered Species Act requirements on the Apalachicola River.

8. FC-3HrsGen ,Z1_3HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure A.09) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor. This parameter is a function of storage and specific hours of generation (2 or 3 hours) that vary by zone.

9. Fish Spawning_Buford

The IF-Blocks and rules (see Figure A.10 through Figure A.13) 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 April 1 through May 31 for Lake Sidney Lanier, 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 H.

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 state variable *Buford_Elev_State* script is used for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator. The lake elevation state is defined as follows:

```
# State variable: Buford_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
```

The state variable *Buford_Elev_State* script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is further described in Appendix H.

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 A.10 and Figure A.11). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure A.12 and Figure A.13):

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

IV. Alternative Operations

Different alternative operation sets were created in the reservoir settings of Buford project to model the impacts of operational measures proposed to improve management of the project. These operational measures include revisions of Buford action zones to better manage the combined composite storages of Lake Lanier, West Point Lake and Walter F. George Lake, the change in Buford hydropower generation rules to constrain generation schedule under drier conditions, and the changes in minimum flow rule at Peach Tree Creek.

For the eight ResSim alternatives, Buford Reservoir used four operation sets. The operation sets used with each alternative are given in Table A.02. Table A.03 describes each operation set.

Table A.02 Alternatives, Operation Sets, and Reservoir Network Used at Buford

Alternative	Operation Set	Reservoir Network
NOAction	NO-Action	2014_base
Alt1	NO-Action	2014
Alt2	Silver	2014
Alt3	Silver	2014
Alt4	Silver	2014
Alt5	Silver	2014
Alt6	Blue	2014
Alt7	Gold	2014

Table A.03 Operation Sets Used at Buford

Operation Set	Description
NO-Action	Current operation / no action.
Silver	Same as NO-Action operation set except Silver uses **Revised Action Zones, Modified Power Generation Schedule with Drought Operation**, and **Seasonal Minimum Flow at Peach Tree Creek**.
Blue	Same as NO-Action operation set except Blue uses **Revised Action Zones** and **Monthly Minimum Flow at Peach Tree Creek**.
Gold	Same as Silver operation set except Gold **triggers Drought Operation at Zone 3** which affects the power generation.

A. *Silver* Operation Set

The Silver operation set for Buford retains all the rules and settings from NO-Action operation set except that Silver uses different elevation of action zones labeled as *Revised* Action Zones, modified power generation Schedule with Drought Operation, and Seasonal Minimum Flow at Peach Tree Creek.

1. Revised Action Zones

Differences in settings in Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. Buford's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised Action Zones are shown in Table A.04, and the comparison to the action zones in NO-Action operation set is shown in Figure A.14.

Table A.04 *Revised* Action Zone Elevations for Silver Operation set at Buford

Zones	1-Jan	1-Feb	1-Mar	15-Apr	1-May	1-Jul	1-Oct	1-Dec
Top of Dam	1106							
Flood Control	1085							
Conservation	1070			1070	1071		1071	1070
Zone 2	1066	1068				1068		
Zone 3	1063	1066.5				1066.5		
Zone 4	1060		1065			1065		
Operating Inactive	1035							

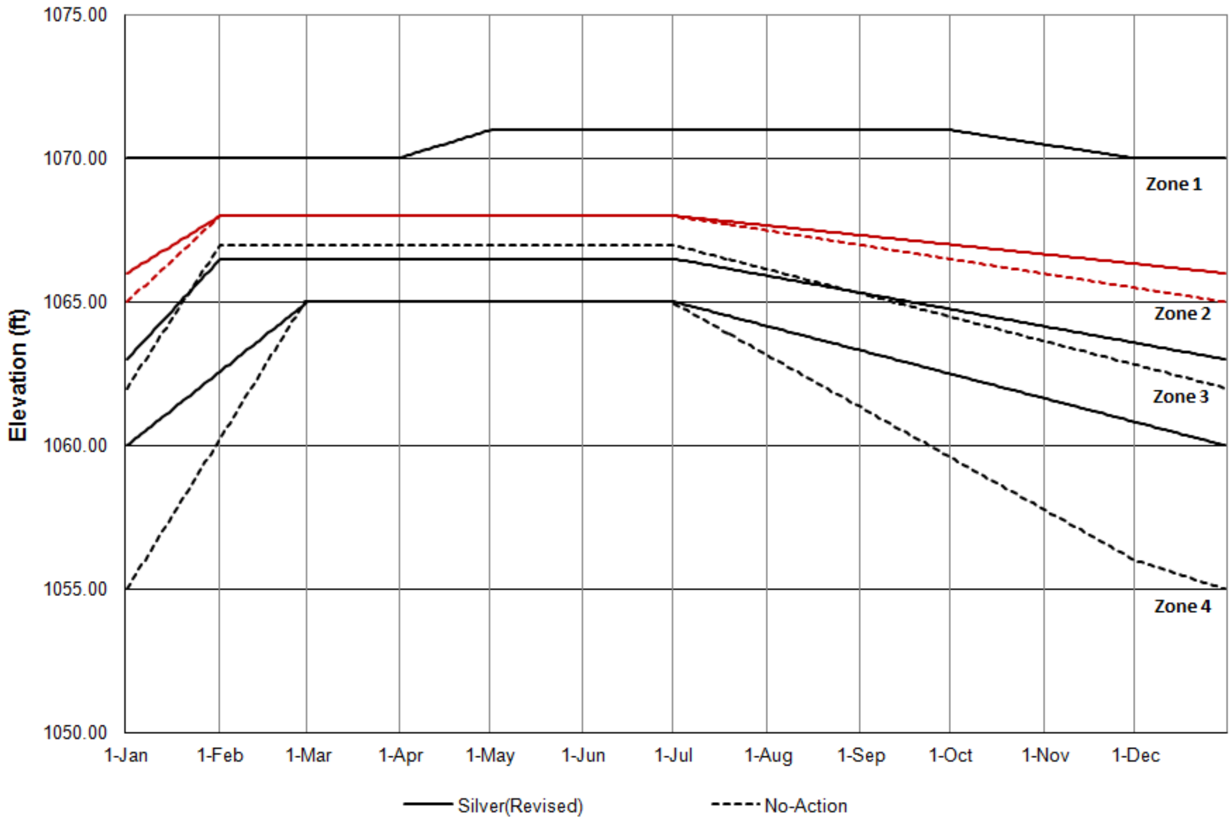


Figure A.14 Comparison of NO-Action and *Revised* Action Zones at Buford

2. Modified Power Generation Schedule with Drought Operation

Updated hydropower generation rules implement the Power Guide Curve operation where the power requirement is defined using a Plant Factor. This parameter is a function of storage and the requirement of specific hours of generation that varies by zone.

The rules are composed of a conditional statement with two rules that are initiated based on the value of the state variable, *DroughtOperations_DO4-1*, which determines whether or not the system's composite storage is within the drought zones. If storage conditions are met and the state variable equals 1, then the first conditional statement initiates an equivalent of 1 or 2 hours of weekday generation at full capacity within Flood Control, Conservation, Zone 2, and Zone 3. If the composite storage state does not meet the conditions in the state variable, the second condition initiates the equivalent of 2 or 3 hours of generation at full capacity. The settings for these rules are shown in Figure A.15 through Figure A.18.

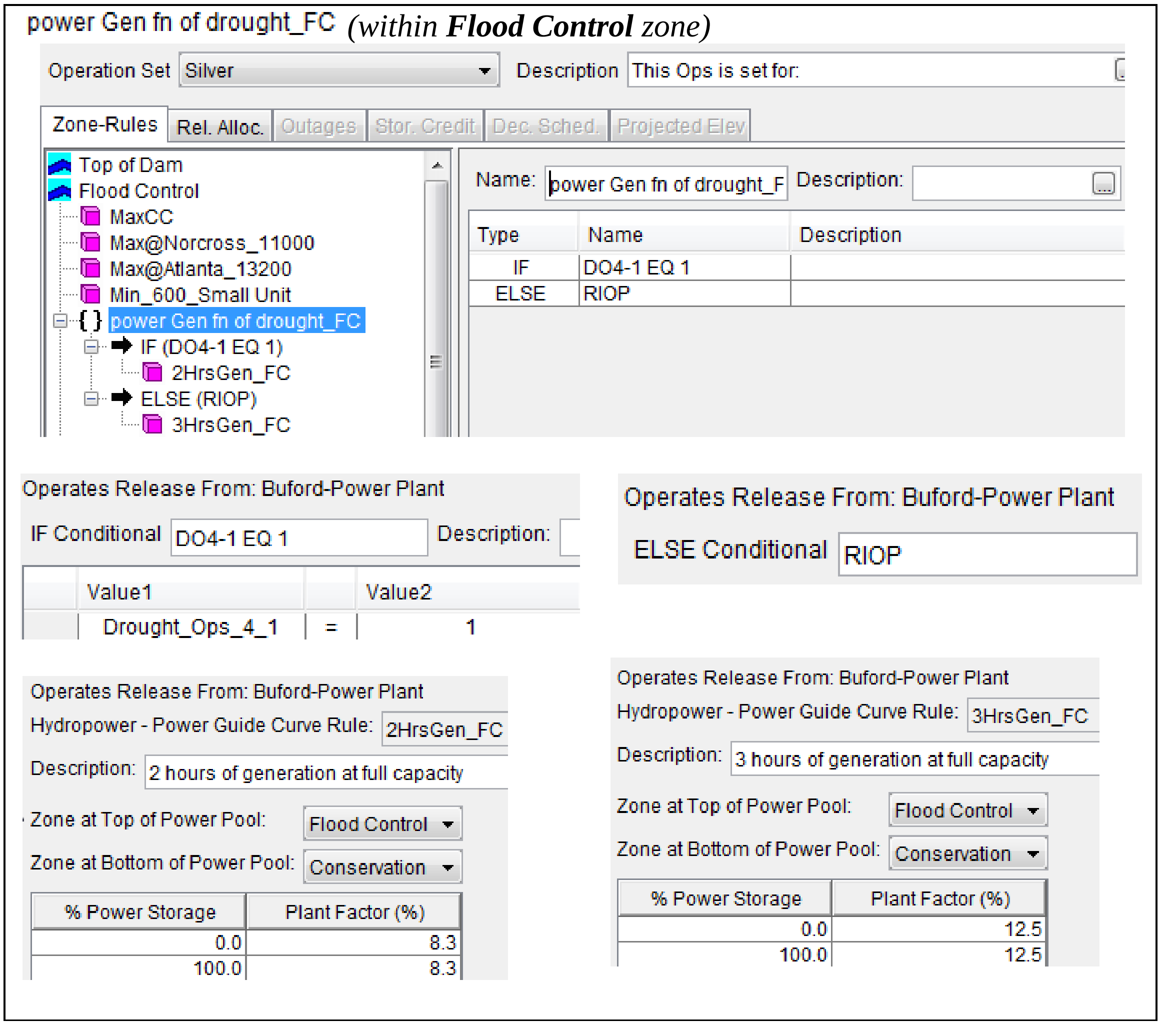


Figure A.15 Silver Operation Set Hydropower Rules for Flood Control Zone

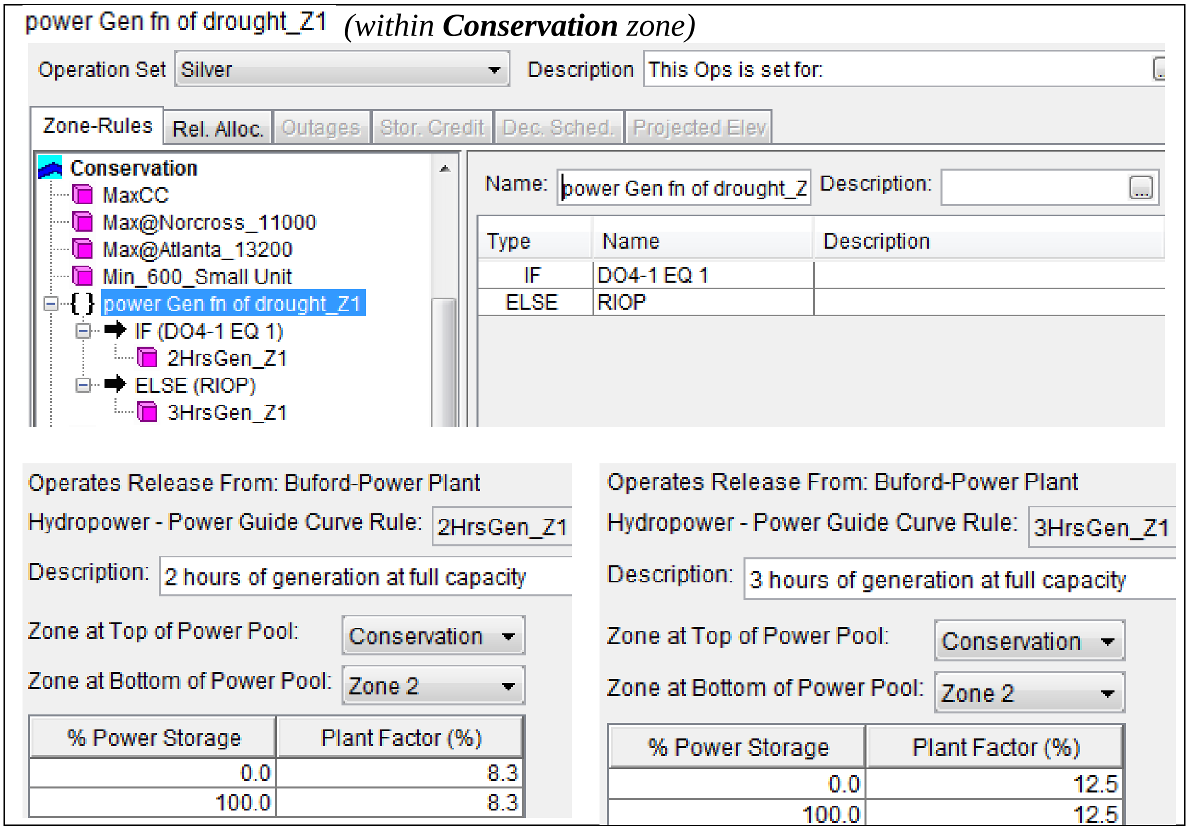


Figure A.16 Silver Operation Set Hydropower Rules for Conservation Zone

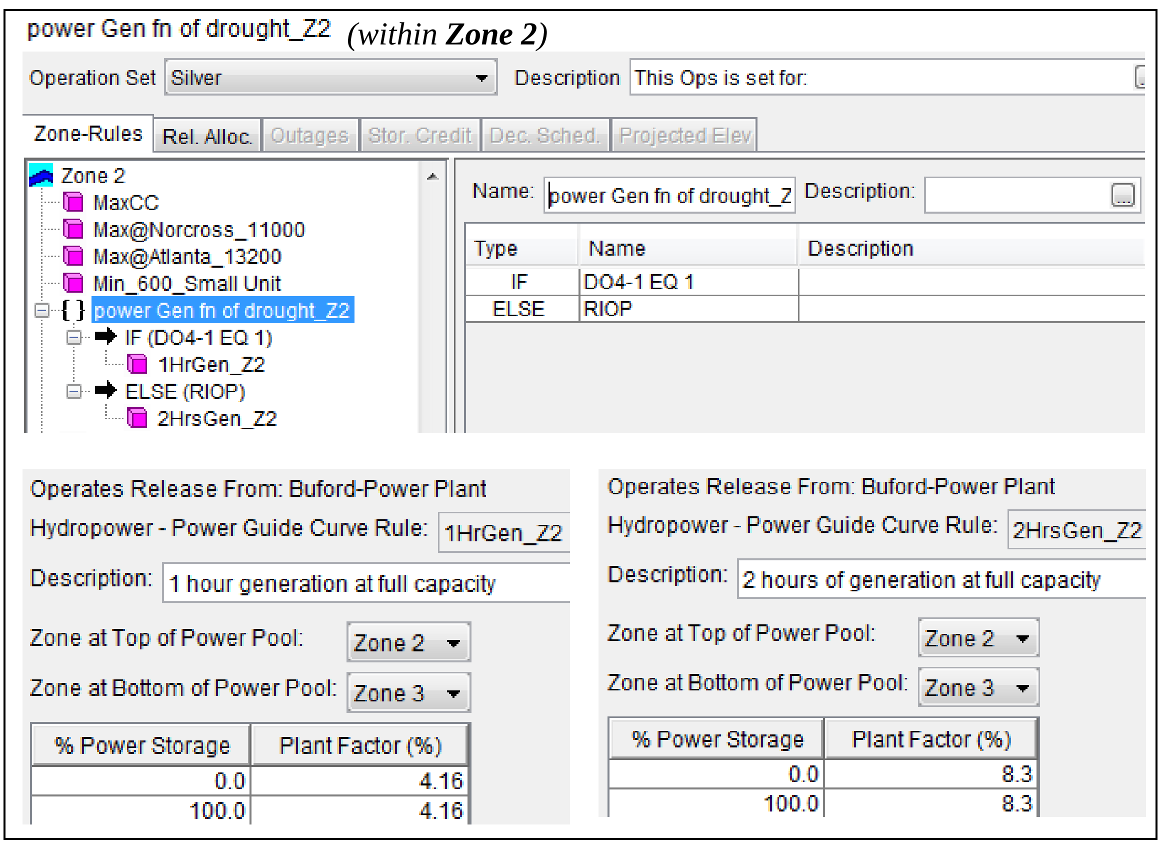


Figure A.17 Silver Operation Set Hydropower Rules for Zone 2

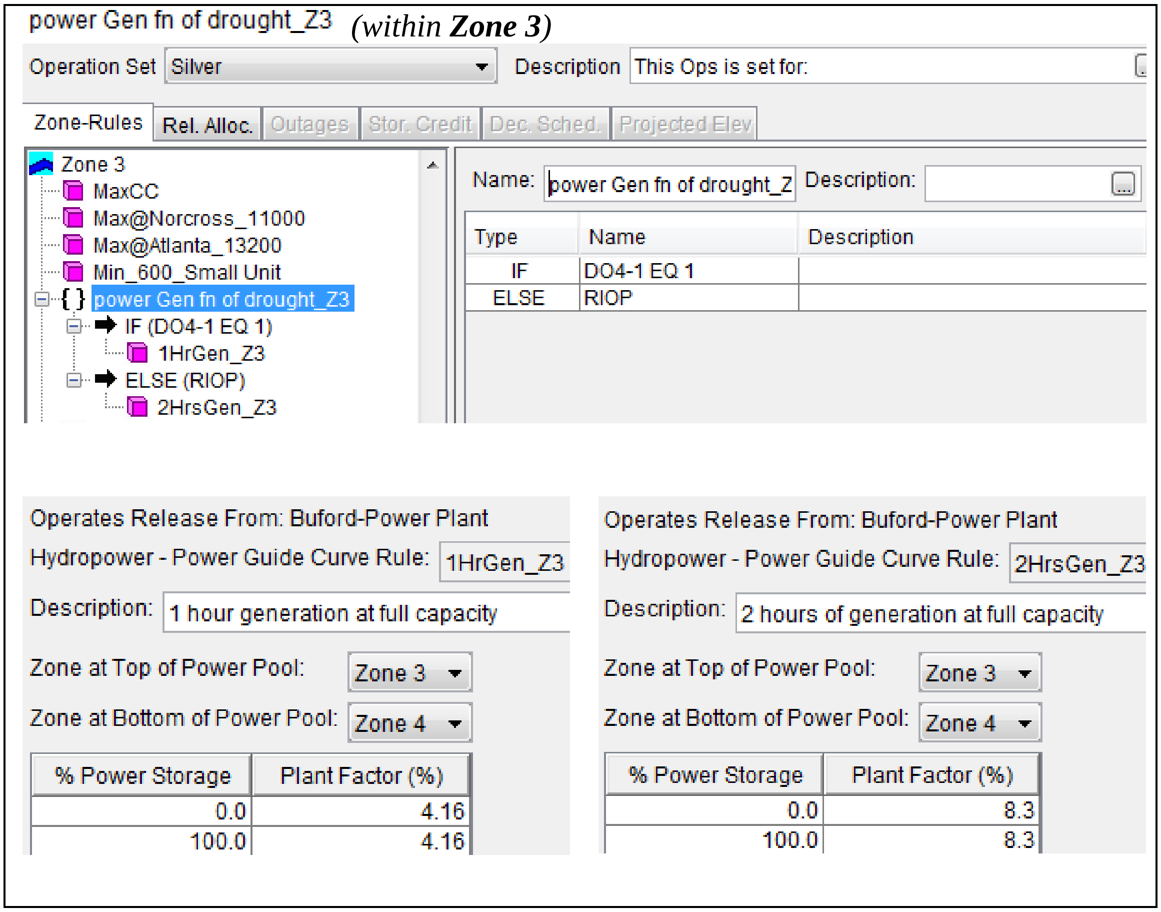


Figure A.16 Silver Operation Set Hydropower Rules for Zone 3

3. Seasonal Minimum Flow at Peach Tree Creek

The Silver operation set modifies the minimum flow rule at Peach Tree Creek to implement a seasonal approach, reflecting the goal to provide a minimum water quality flow of 750 cfs in Chattahoochee during May-Oct, and 650 cfs during Nov-Apr. The model uses 800 cfs and 700 cfs respectively to add a “factor of safety” to guarantee the minimum flow. Description of the rule is shown in Figure A.19.

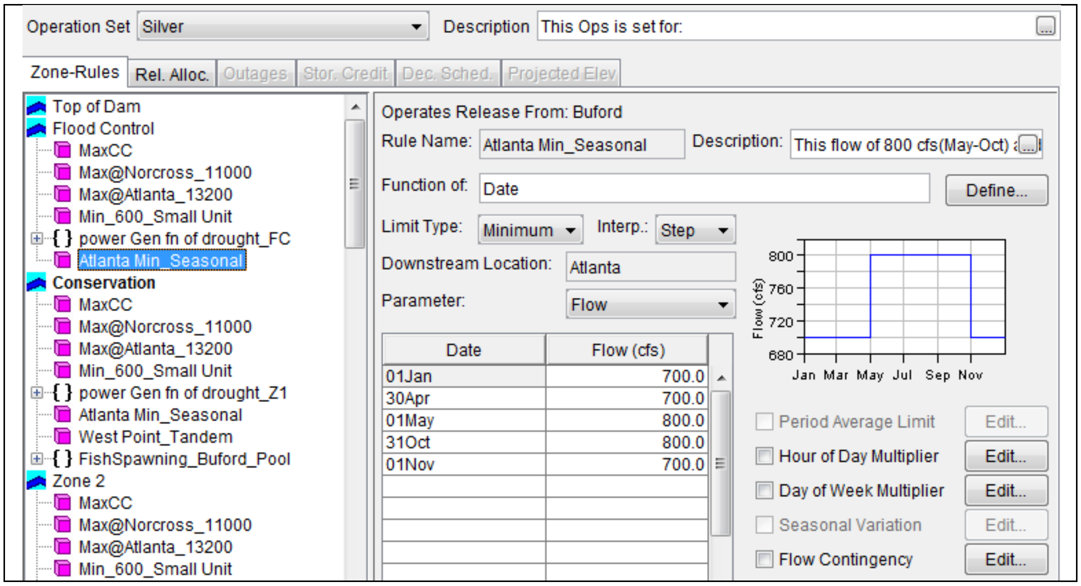


Figure A.17 Silver Operation Set Seasonal Minimum Flow rule at Peach Tree Creek

B. *Blue* Operation Set

The Blue operation set for Buford retains all the rules and settings from NO-Action operation set except that Blue uses Revised Action Zones and monthly Minimum Flow at Peach Tree Creek. The revised action zones are the same as Silver shown in Table A.04.

1. Monthly Minimum Flow at Peach Tree Creek

The Blue operation set modifies the minimum flow rule at Peach Tree Creek to implement monthly rules to provide a minimum water quality flow in Chattahoochee just upstream from the junction with Peachtree Creek. The composite storage of the system (i.e., state variable CompositeStorage) determines which of four monthly flow patterns apply. This minimum flow rule is implemented identically to each Buford Zone above Operating Inactive, and is described in Figure A.20.

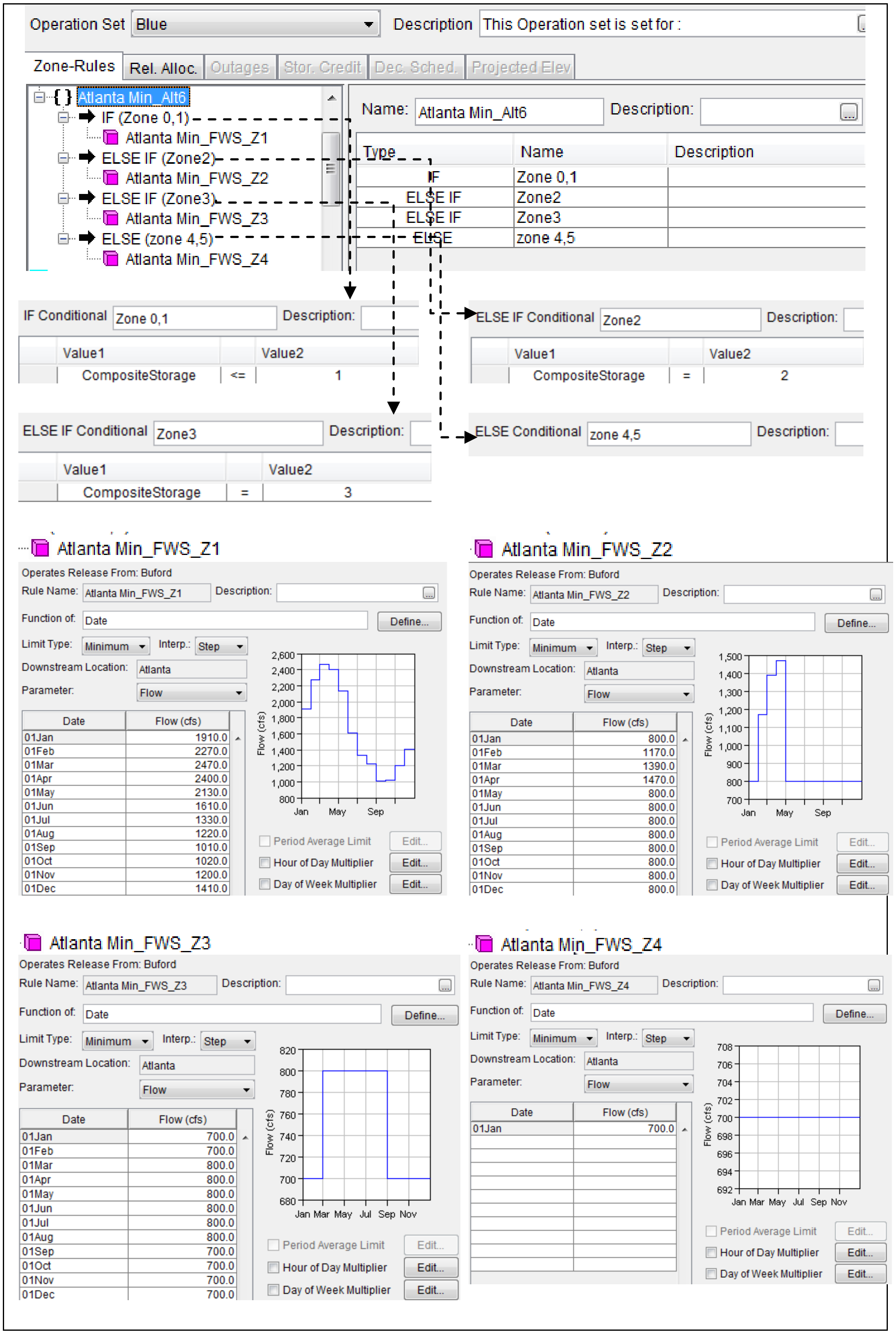


Figure A.18 Blue Operation Set Monthly Minimum Flow rule at Peach Tree Creek

C. *Gold Operation* Set

The Gold operation set for Buford retains all the rules and settings from Silver operation set except that Gold triggers drought operation at zone 3 which affects hydropower rule description. These rules are shown in Figure A.21.

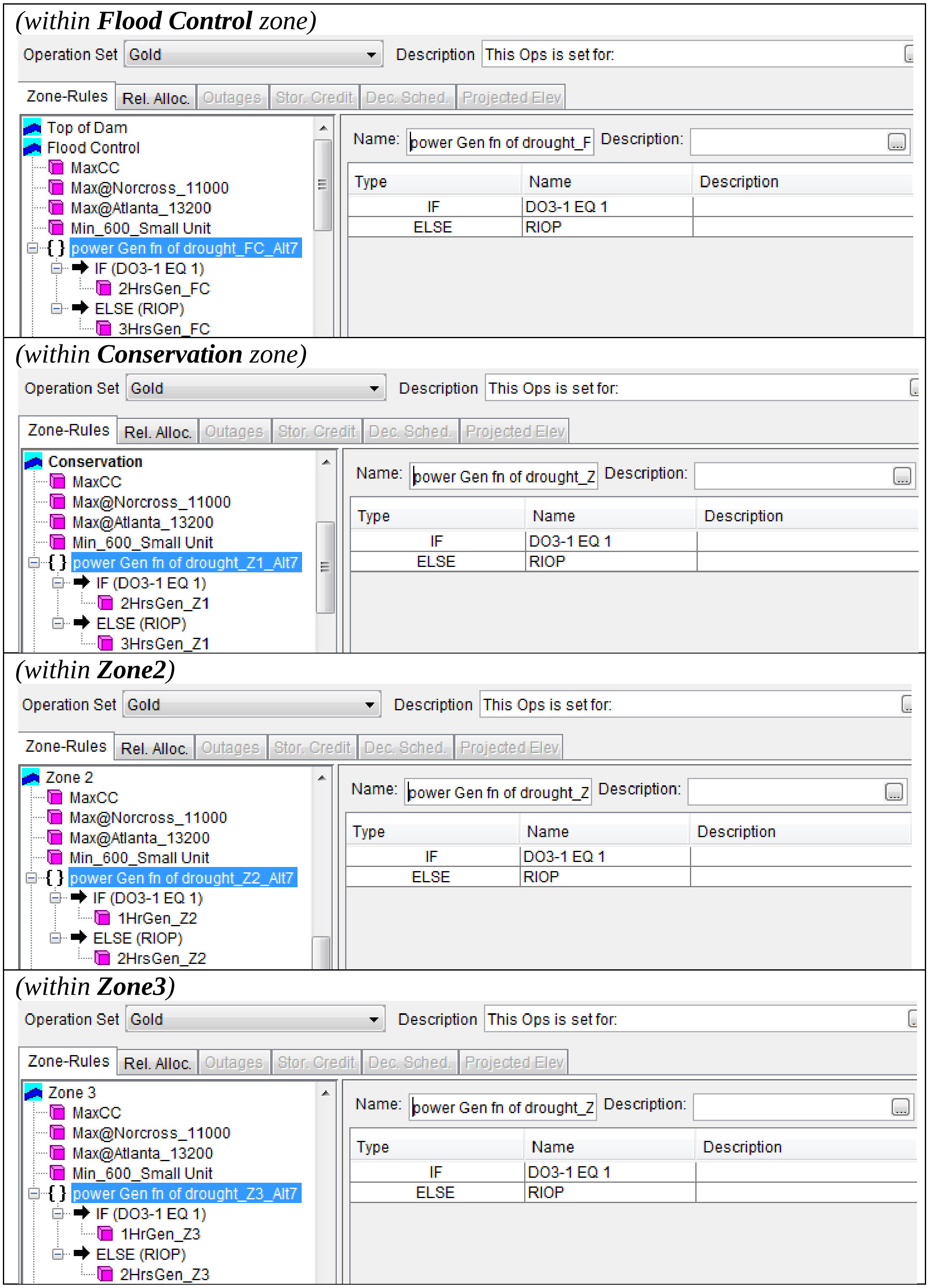


Figure A.19 Gold Operation Set Hydropower Rules

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix B – West Point

June 2014

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Appendix B – West Point

Table of Contents:

List of Tables:

List of Figures:

West Point (West Point Lake)

I. Overview

West Point Lake and Dam is a multipurpose project located on the Alabama-Georgia state line near West Point, Georgia. The authorized purposes for the reservoir are flood damage reduction, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply. The Mobile District of the Corps of Engineers operates the project for flood control to reduce flood damages along the reach of the Chattahoochee River between West Point Dam and Columbus, as well as the other authorized purposes. Flood conditions are closely monitored at the West Point gage location. In the conservation zone, West Point Lake is involved in the system operation through tandem operation to meet the Endangered Species Act (ESA) requirements for the Apalachicola River below Jim Woodruff Dam. Due to its location in the watershed and basin hydrology, West Point Lake has a larger drainage area than Lake Lanier and is therefore easier to refill.

For the recommended plan, the guide curve is revised to represent a modification to the current flood operation for West Point Dam. An hourly flood model was specifically developed to evaluate whether or not modifications to the flood operation will increase flood damages downstream. For details about the West Point flood analysis, refer to Appendix I.

Figure B.01 shows the location of West Point Dam and its pool (West Point Lake) as it is represented in the HEC-ResSim model, and Figure B.02 shows a photo of West Point Dam.

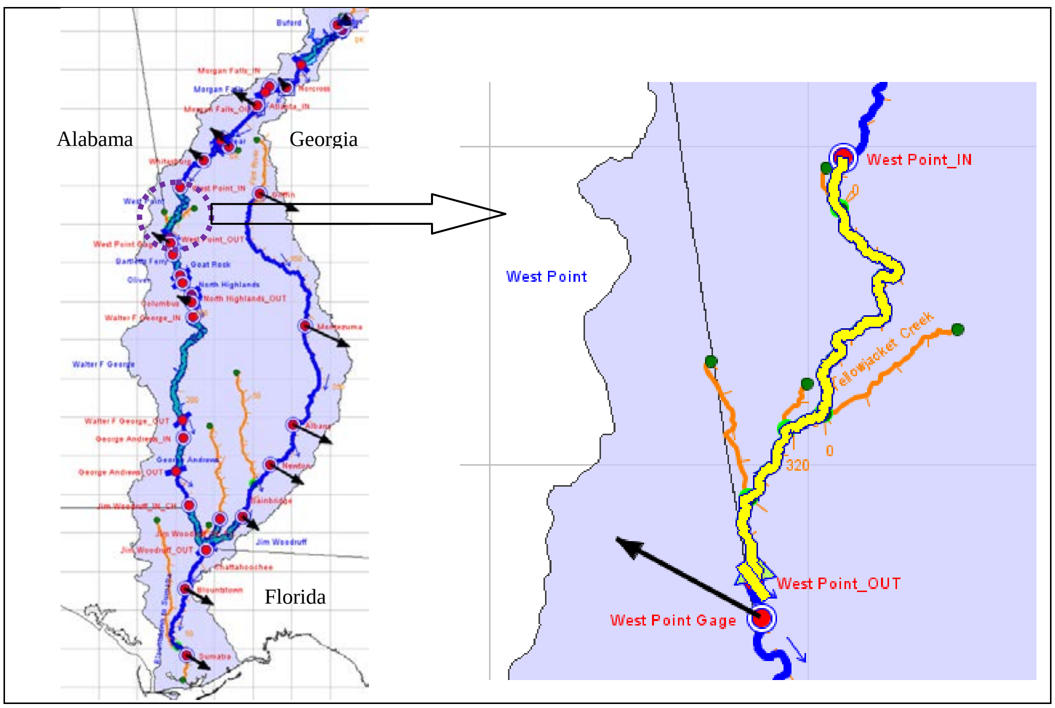


Figure B.01 HEC-ResSim Map Display Showing Location of West Point

Figure B.02 Photo of West Point Dam

II. Physical Characteristics

The West Point project consists of a gravity-type concrete dam 896 ft long with earthen embankments 1,111 ft long on the east end and 5,243 ft long on the west end. The total length of the dam and spillway is 7,250 ft. The main dam consists of a concrete non-overflow section, 185 ft long on the west side, and an earthen embankment retaining wall on the east side, as well as a concrete spillway 390 ft long, including piers and abutments, with six tainter gates, each 50 ft by 41 ft. A monolith intake-powerhouse section and erection bay 321 ft long is constructed directly west of and adjacent to the spillway.

At the top of conservation pool (elevation of 635 ft), the reservoir provides a total storage of 604,516 ac-ft, of which 306,127 ac-ft is available conservation storage and 298,389 ac-ft is inactive storage. In addition, 85,200 ac-ft is reserved for flood storage between pool elevations 635 ft and 641 ft. During the critical flood season, the reservoir is operated with a maximum conservation pool elevation of 628 ft to provide additional flood damage reduction storage. West Point Lake has a surface area of 25,864 acres at elevation of 635 ft. The power installations consist of one 4-MW generating unit and two units of 42 MW each, for a total of 88MW.

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

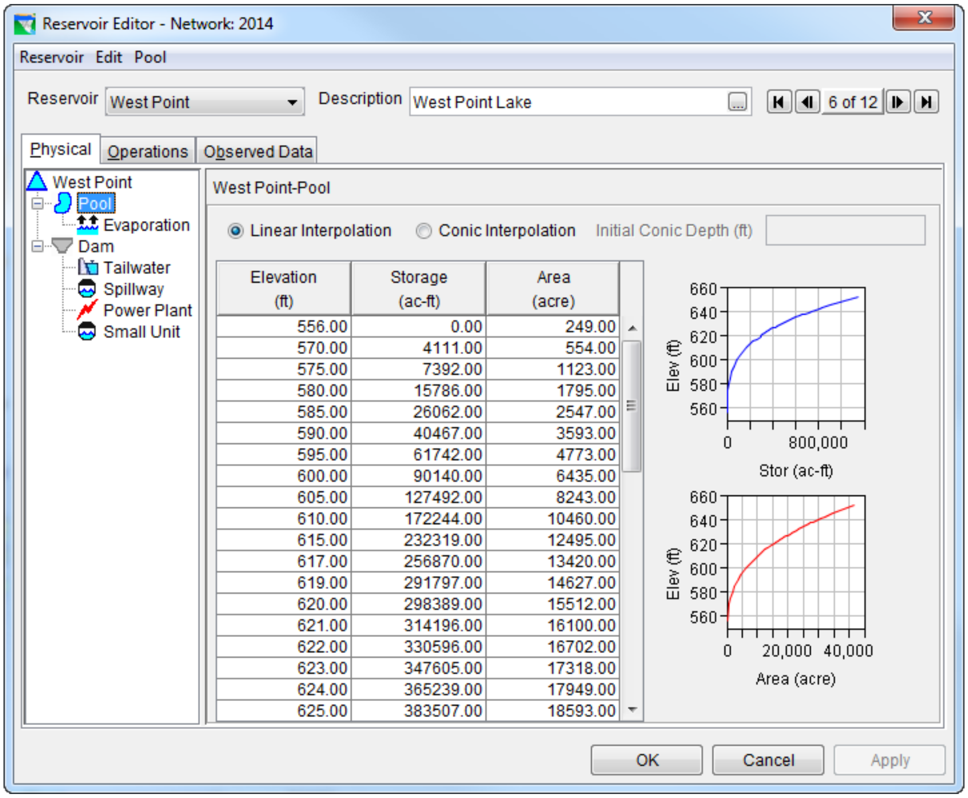


Figure B.03 Reservoir Editor- Network 2014: Physical Tab -- Pool

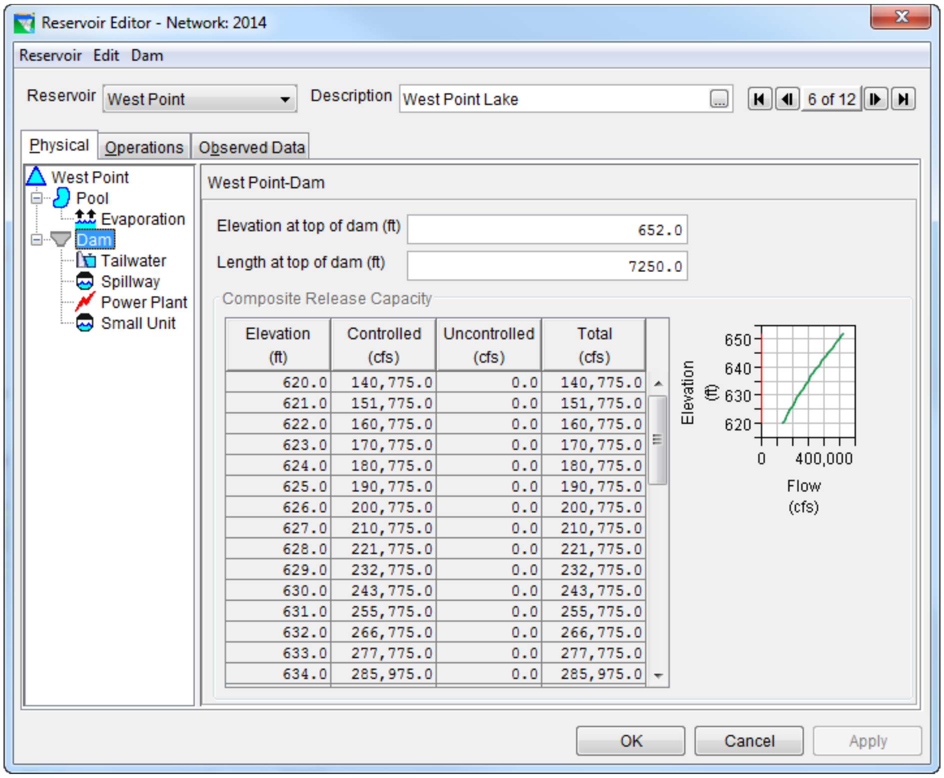


Figure B.04 Reservoir Editor- Network 2014: Physical Tab – Dam

III. NOAction Operations

West Point Dam provides a continuous minimum release of 675 cfs to the Chattahoochee River. It operates in a peaking mode, generating power for 2 to 4 hours during normal operations each weekday depending on the conservation pool elevation. Lake levels vary only during high inflows to the basin and during flood storage drawdown in the winter. Flood flows captured in the reservoir are generally released slowly over the subsequent weeks, unless additional flood flows are expected. Power releases during the low-flow season augment flows at the Georgia Power Company projects along the Chattahoochee River. The releases also provide water for municipal and industrial needs in the Columbus, Georgia, area and for navigation on the Apalachicola River below Jim Woodruff Lock and Dam during the winter.

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 West Point's "NO-Action" operational zones, which consist of zones of flood control and conservation.

Table B.01 Zone Elevations for "NO-Action" Operation Set

West Point	NO-Action Top of **Zone Elevation** Values (feet) Blue values = entered; Black *italic* values = assumed; Orange linear = linear-interpolated values									
Seasons =	**1-Jan**	**1-Feb**	**15-Feb**	**1-May**	**1-Jun**	**1-Jul**	**1-Sep**	**1-Nov**	**1-Dec**	**15-Dec**
Zones:										
Top of Dam	652	*652*	*652*	*652*	*652*	*652*	*652*	*652*	*652*	*652*
Flood Control	641	*641*	*641*	*641*	*641*	*641*	*641*	*641*	*641*	*641*
Conservation	628	*628*	628	linear	635	*635*	*635*	635	linear	628
Zone 2	624	624	linear	632.5	633	633	632	linear	624	*624*
Zone 3	623	623	linear	632	*632*	632	linear	linear	623	*623*
Zone 4	621	621	linear	630	630	linear	linear	linear	621	*621*
Inactive	620	*620*	*620*	*620*	*620*	*620*	*620*	*620*	*620*	*620*

The top of the operation zones vary seasonally (as shown in Figure B.05). These zones are used in balancing the system through tandem operations to meet the ESA release requirements from Jim Woodruff. They are also used to define the composite action zones and track the active composite zone to determine flow releases together with basin inflow and operating seasons in accordance with the requirements in RIOP. The seasonal ordinates of the action zones are provided by the Mobile District.

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

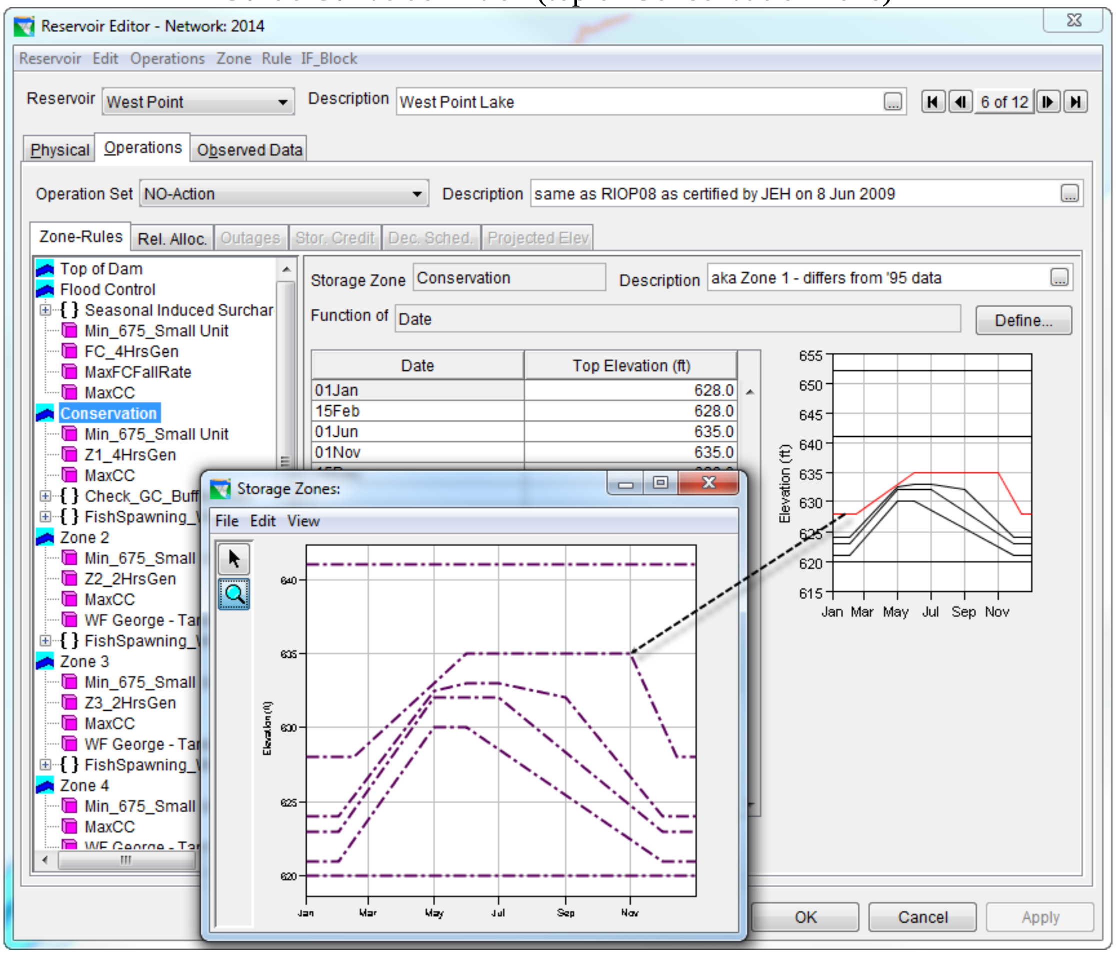


Figure B.05 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

Figure B.06 shows a sequential release allocation approach specified for available outlets along West Point 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 gated spillway.

Release Allocation:

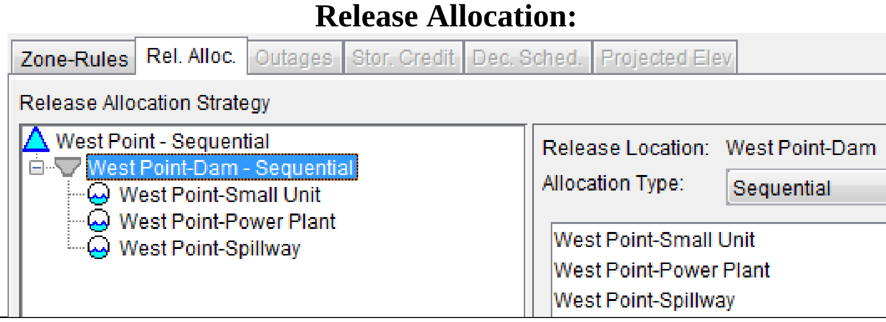


Figure B.06 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

Figure B.07 shows a set of operational rules specified for each zone that reflects the operation set named “NO-Action”.

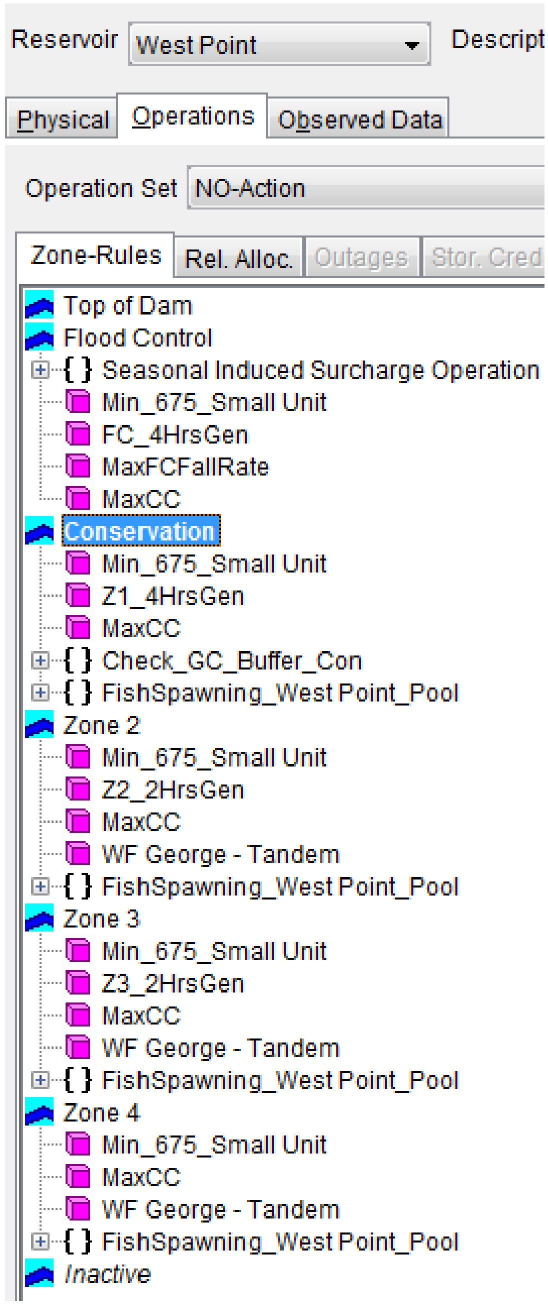


Figure B.07 Reservoir Editor- Network 2014: Operations Tab– NO-Action OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure B.08 through Figure B.12. The logic and purpose for each operational rule is described in Section C.

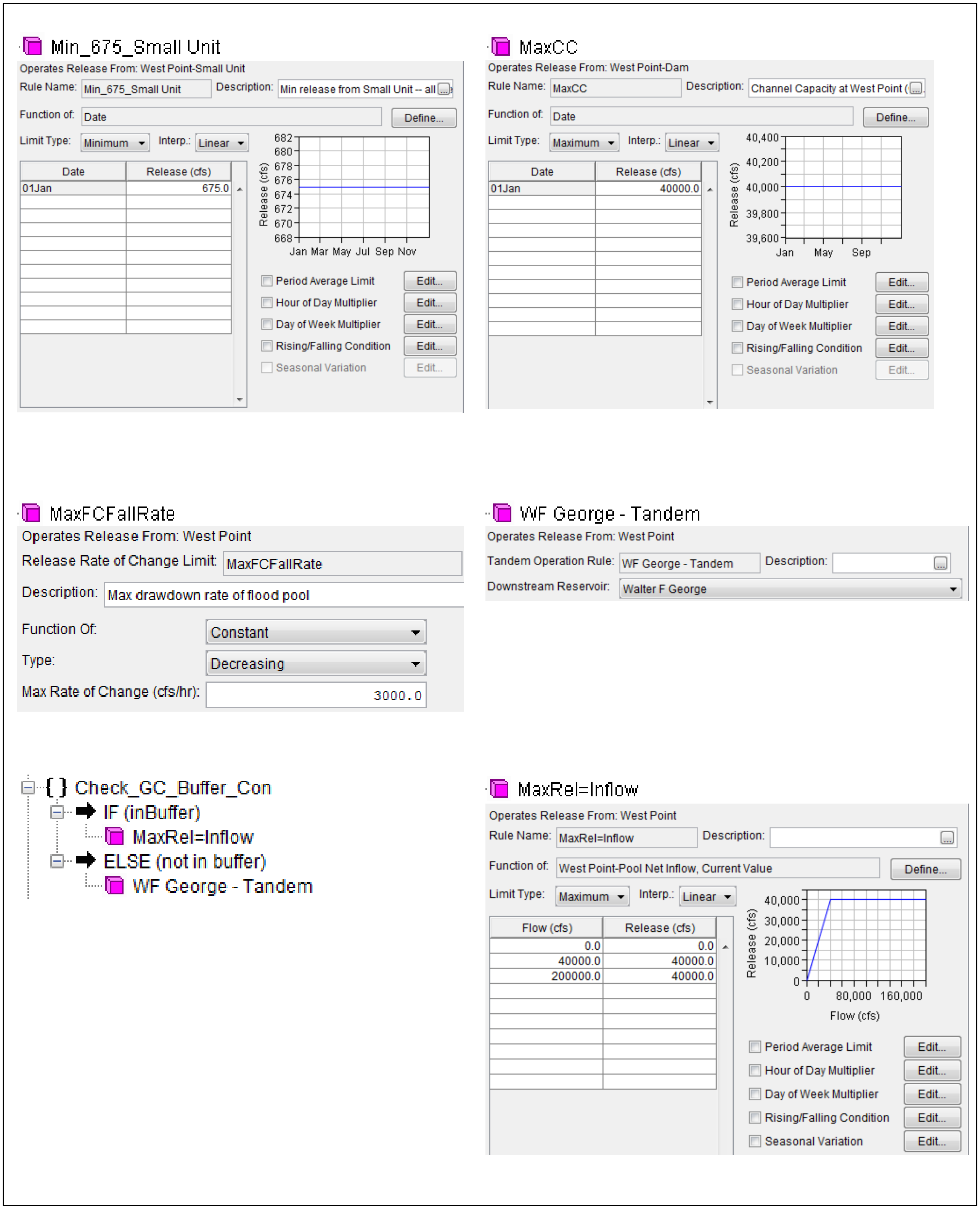
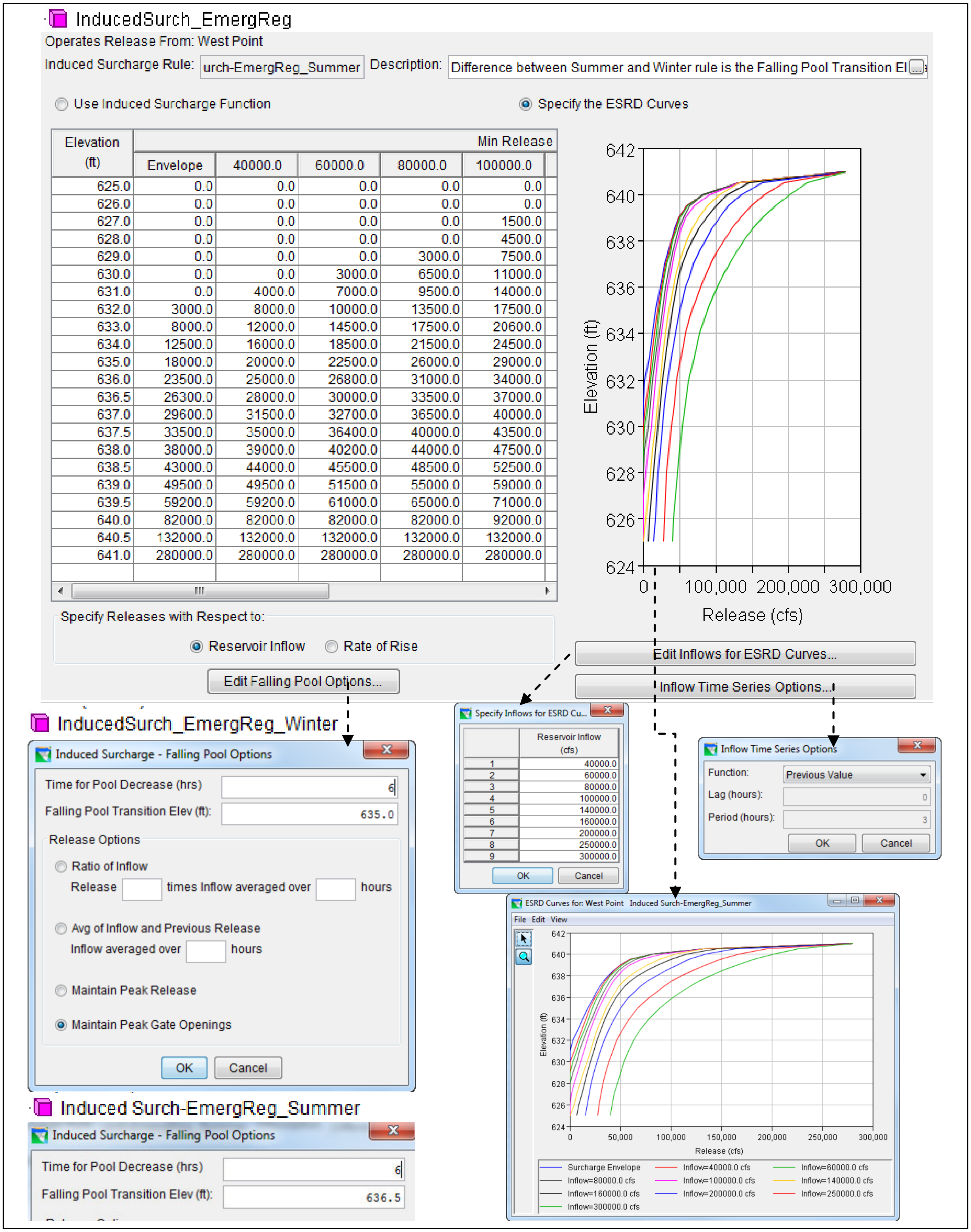


Figure B.08 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Max, Min, and Tandem Rules



Elevation (ft)	Envelope	40000.0	60000.0	80000.0	100000.0
625.0	0.0	0.0	0.0	0.0	0.0
626.0	0.0	0.0	0.0	0.0	0.0
627.0	0.0	0.0	0.0	0.0	1500.0
628.0	0.0	0.0	0.0	0.0	4500.0
629.0	0.0	0.0	0.0	3000.0	7500.0
630.0	0.0	0.0	3000.0	6500.0	11000.0
631.0	0.0	4000.0	7000.0	9500.0	14000.0
632.0	3000.0	8000.0	10000.0	13500.0	17500.0
633.0	8000.0	12000.0	14500.0	17500.0	20600.0
634.0	12500.0	16000.0	18500.0	21500.0	24500.0
635.0	18000.0	20000.0	22500.0	26000.0	29000.0
636.0	23500.0	25000.0	26800.0	31000.0	34000.0
636.5	26300.0	28000.0	30000.0	33500.0	37000.0
637.0	29600.0	31500.0	32700.0	36500.0	40000.0
637.5	33500.0	35000.0	36400.0	40000.0	43500.0
638.0	38000.0	39000.0	40200.0	44000.0	47500.0
638.5	43000.0	44000.0	45500.0	48500.0	52500.0
639.0	49500.0	49500.0	51500.0	55000.0	59000.0
639.5	59200.0	59200.0	61000.0	65000.0	71000.0
640.0	82000.0	82000.0	82000.0	82000.0	92000.0
640.5	132000.0	132000.0	132000.0	132000.0	132000.0
641.0	280000.0	280000.0	280000.0	280000.0	280000.0

Figure B.09 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Induced Surcharge Rule

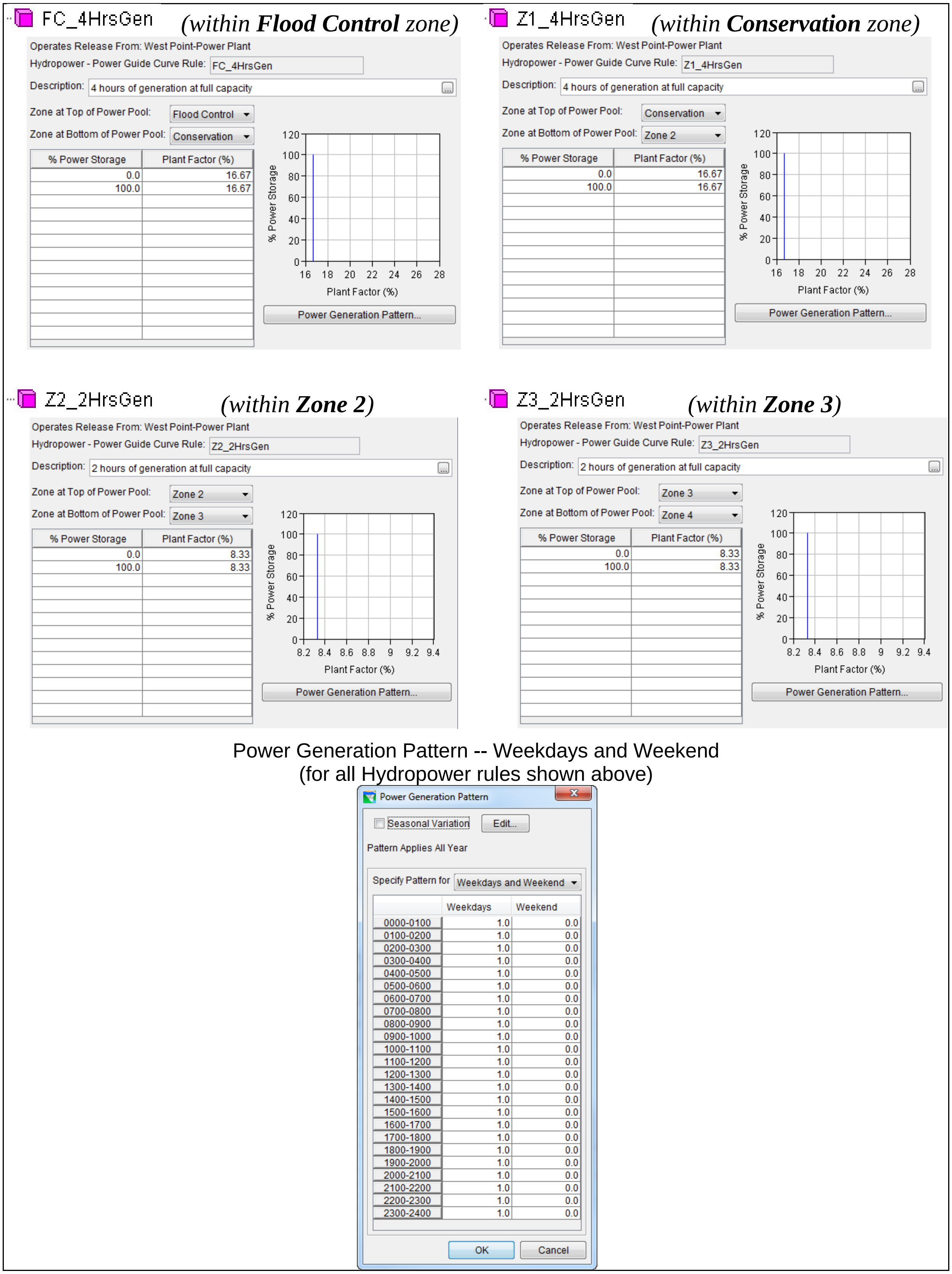


Figure B.10 Reservoir Editor: Operations Tab – NO-Action OpSet – Hydropower Rules

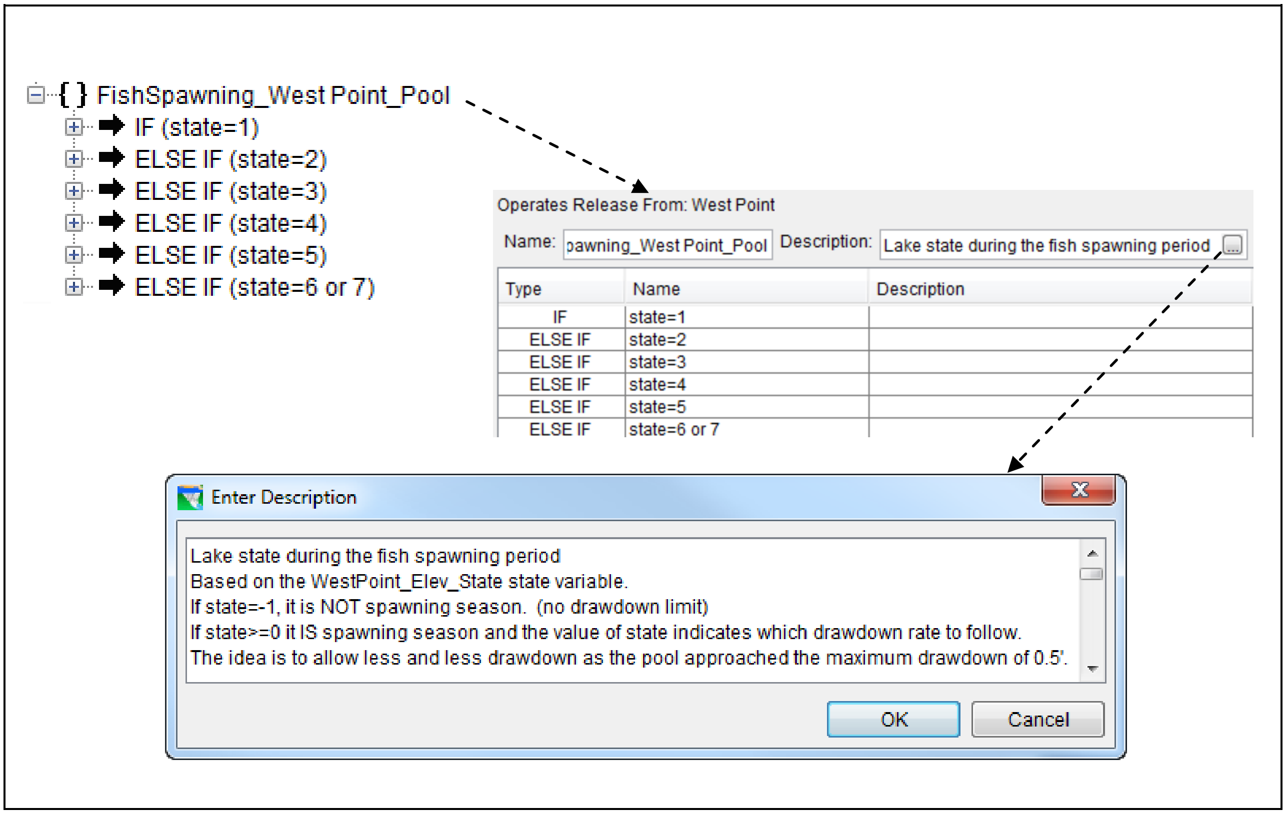


Figure B.11 Fish Spawning -- "Conditional Blocks"

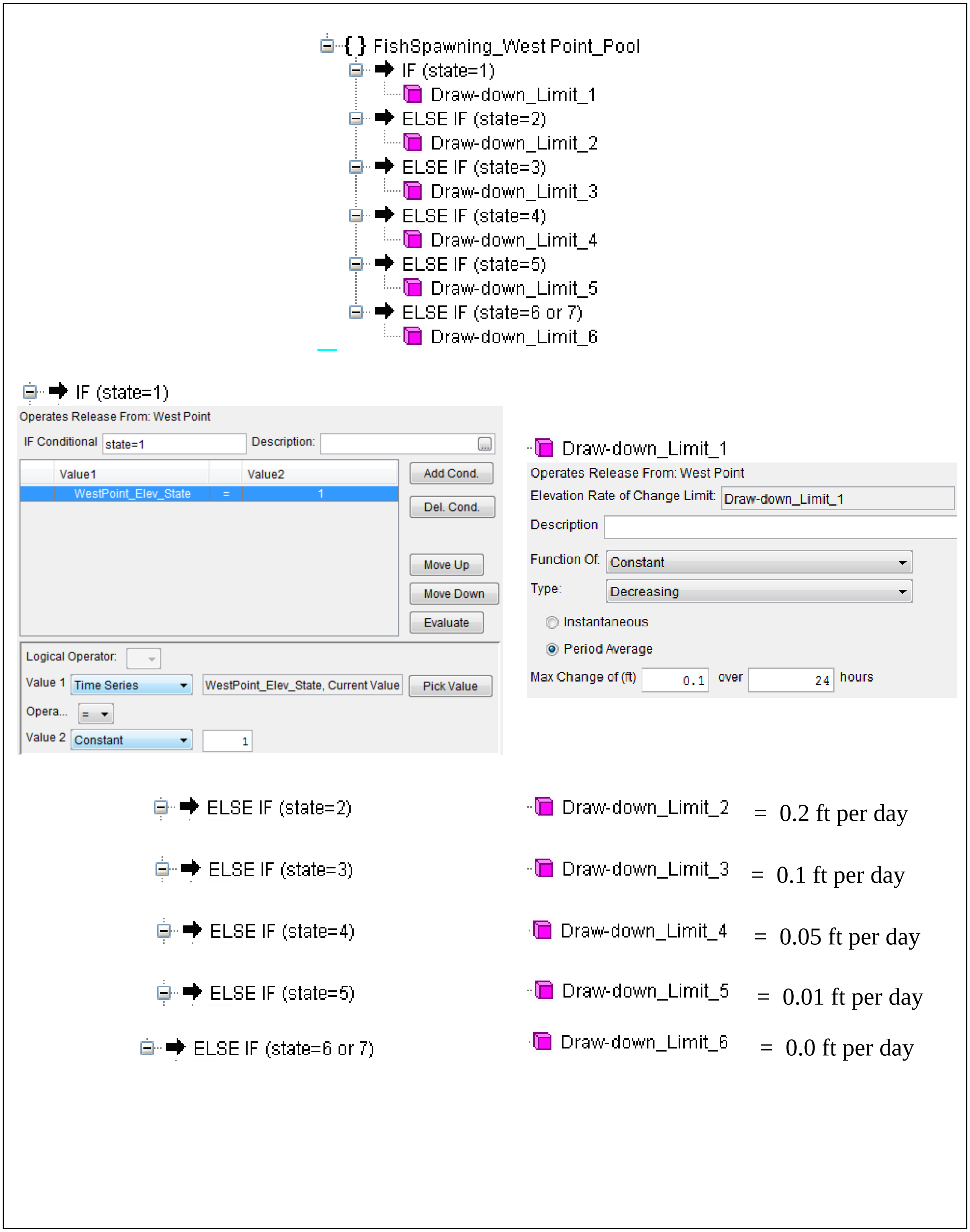


Figure B.12 Fish Spawning -- "IF-Blocks" and "Rules" and "WestPoint_Elev_State" Values

C. Rule Descriptions

1. *Min_675_Small Unit*

This rule (see Figure B.08) represents the flow release from the small unit, which is in use continuously throughout the year. Once the unit is on, the flow release is at approximately a constant of 675 cfs.

2. *MaxCC*

This rule (see Figure B.08) sets a maximum release from West Point Dam to the channel capacity (40,000 cfs) of the Chattahoochee River just downstream of the dam.

3. *MaxFCFallRate*

This rule (see Figure B.08) sets the maximum rate of change for falling releases (when in the flood control pool) at 3,000 cfs per hour.

4. *WF George - Tandem*

This rule (see Figure B.08) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F George, and Lake Seminole to meet the Endangered Species Act (ESA) requirements on the Apalachicola River.

5. *{ } Check_GC_Buffer_Con*

This IF-Block (see Figure B.08) represents a modeling technique to minimize oscillations of the HEC-ResSim results. After much testing, it was found that the problem of the oscillations appeared when the pool elevation at West Point is adjacent to the West Point guide curve and when the pool elevation at Walter F George is at or above the Walter F George guide curve. A state variable (see Appendix H) named *WestPoint_GCBuffer*, was created to define a buffer zone around the West Point guide curve. The IF-Block set of conditional logic was created to define these two conditions, under which tandem operation is turned off. The release is then limited to the net inflow to West Point Lake up to the downstream channel capacity, which is 40,000 cfs. The operation rule associated with this flow release requirement is *MaxRel=Inflow* (see Figure B.08).

6. *Seasonal Induced Surcharge Operation*

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 releases to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. An induced surcharge rule requires an induced surcharge schedule, which is a family of curves of spillway discharges and pool elevations for a range of reservoir inflows. In the daily model, the inflow at the previous time step is used. The induced surcharge schedule includes an induced surcharge envelope curve that represents the maximum reservoir levels that would be permitted at various rates of spillway discharge when operating under the induced surcharge plan. The induced surcharge rule also includes falling pool options. The *Time for Pool Decrease* (6 hours) 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* is the pool elevation below which the induced surcharge rule will no longer operate. This elevation is set to 635 ft in winter and 636.5 in summer. The *Release Options* assign the method for computing falling pool releases. For West Point Dam, the option of *Maintain Peak Gate Openings* is selected.

7. FC_4HrsGen, Z1_4HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure B.10) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor, which is a function of storage, and the requirement (4 or 2 hours of generation) varies by zones.

8. Fish Spawning_West Point

The IF-Blocks and rules (see Figure B.11 and Figure B.12) 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 April 1 through June 1 for West Point Lake, 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 G.

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: WestPoint_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
```

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

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.12). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure B.12):

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

IV. Alternative Operations

West Point Dam is one of the critical elements in the ACF system. In updating the Water Control Manual, West Point's action zones are revised to improve the management of the combined composite storages of Lake Lanier, West Point Lake, and Walter F George. For the eight ResSim alternatives, West Point Reservoir used two 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, Operation Sets, and Reservoir Network Used at West Point

Alternative	Operation Set	Reservoir Network
NOAction	NO-Action	2014_Base
Alt1	NO-Action	2014
Alt2	Silver	2014
Alt3	Silver	2014
Alt4	Silver	2014
Alt5	Silver	2014
Alt6	Silver	2014
Alt7	Silver	2014

Table B.03 Operation Sets Used at West Point

Operation Set	Description
NO-Action	Current operation / no action.
Silver	Same as NO-Action operation set except Silver uses **Revised Action Zones**.

A. Silver Operation Set

Silver operation set for West Point retains all the rules and settings from NO-Action operation set except this operation set uses different elevation of action zones labeled as *Revised* Action Zones.

1. Revised Action Zones

Differences in settings in the Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. West Point's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised action zones are shown in Table B.04, and the comparison to the action zones in NO-Action operation set is shown in Figure B.13 .

Table B.04 *Revised* Action Zone Elevations for Silver Operation Set at West Point

Zones	1-Jan	1-Feb	15-Feb	1-May	1-Jun	1-Jul	1-Sep	1-Nov	1-Dec	15-Dec
Top of Dam	652									
Flood Control	641									
Conservation	628		628		635			635		628
Zone 2	627.5		627.5	632.25	632.5		632.5		627.5	
Zone 3	623	623		632		632	629.5		623	
Zone 4	621	621		631	631				621	
Inactive	620									

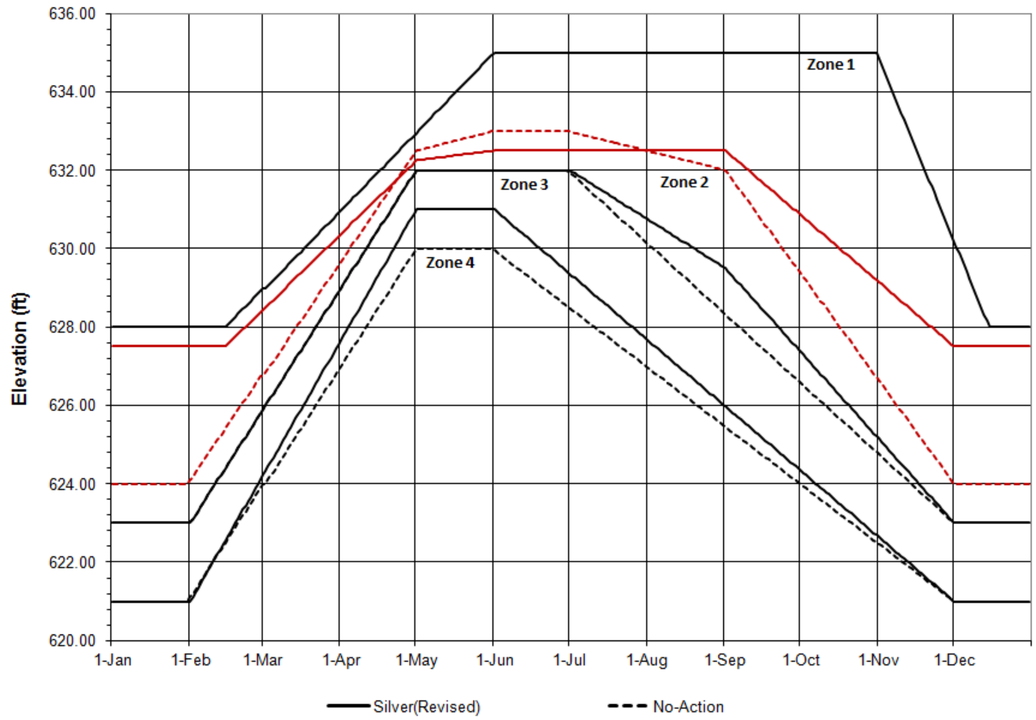


Figure B.13 Comparison of NO-Action and *Revised* Action Zones at West Point

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix C – Walter F. George (Lake Eufaula)

June 2014

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Appendix C – Walter F. George

Table of Contents:

List of Tables:

List of Figures:

Walter F. George (Lake Eufaula)

I. Overview

The authorized purposes for the Walter F. George Dam and Reservoir include flood control, fish and wildlife enhancement, hydroelectric power generation, navigation, and water quality. Walter F. George is operated by the Mobile District of the Corps of Engineers according to specified flood control schedules. During the principal flood season, December through April, the regulation plan at Walter F. George provides for low lake levels to ensure lower peak stages throughout the reservoir during major floods.

The major physical operating constraint that takes precedence over all others is structural head limitations, the difference between the headwater and tailwater, which must not exceed 88 ft at any time. In addition to meeting the needs of all project purposes, Walter F. George also operates as part of a system to meet project purposes at other projects in the ACF basin.

Figure C.01 shows the location of Walter F. George Dam and its pool (Lake Eufaula) as it is represented in the HEC-ResSim model, and Figure C.02 shows a photo of Walter F. George Dam.

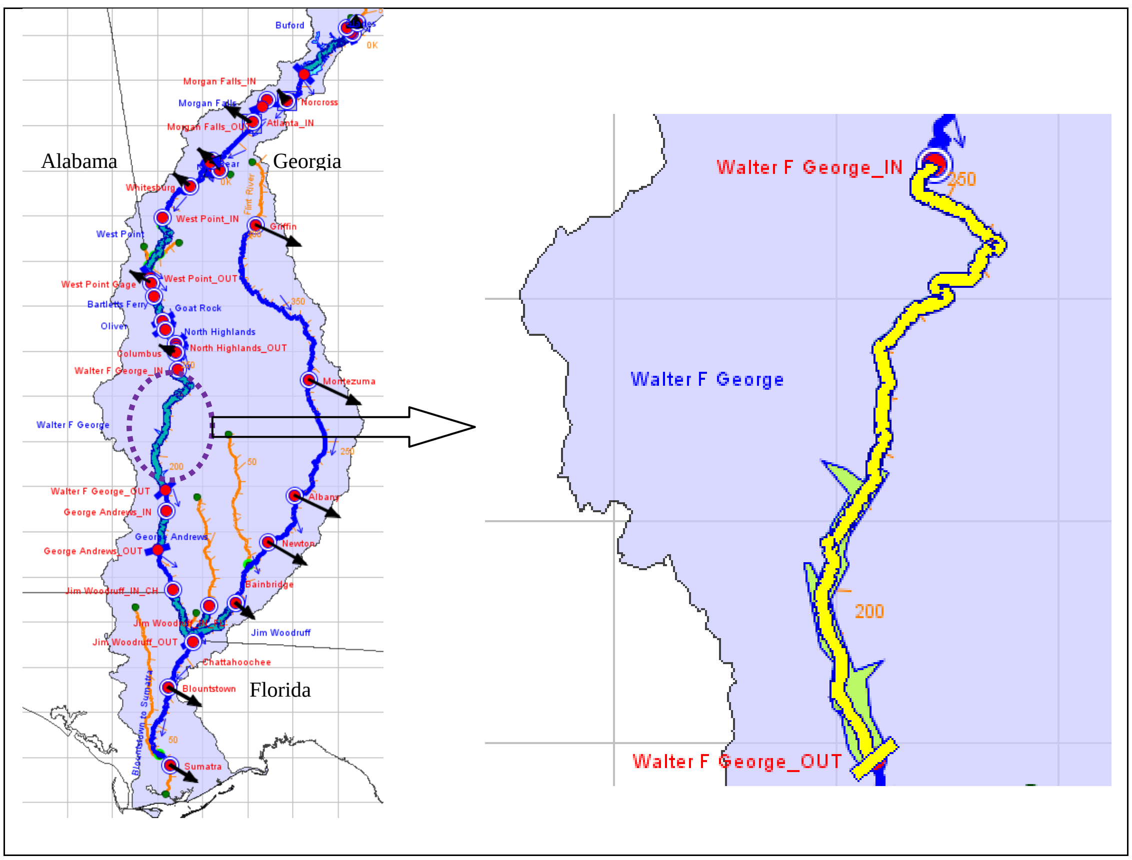


Figure C.01 HEC-ResSim Map Display Showing Location of Walter F. George

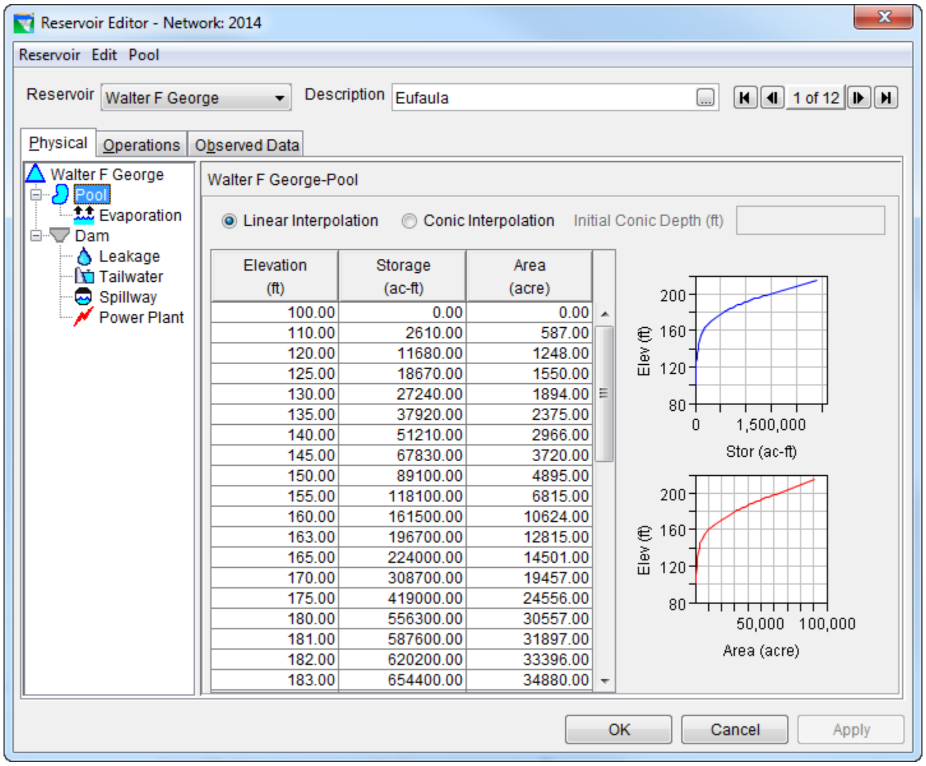
Figure C.02 Photo of Walter F. George Dam

II. Physical Characteristics

Walter F. George Lake, also known as Lake Eufaula, is created by the Walter F. George Lock and Dam on the Chattahoochee River about 183 miles upstream of Apalachicola Bay. The existing project is composed of a concrete dam, gated spillway, and single-lift lock, with earthen embankments at either side. The non-overflow section of the dam includes a 200 ft long concrete dam, a powerhouse and an intake structure, with the deck of the powerhouse section at elevation 208 ft. The gated spillway is 708 ft long with a fixed crest at elevation 163 ft. The two earthen embankments, almost equal in length, have a total length of 12,128 ft, with crest elevation at 215 ft and a maximum height of about 68 ft. The lock, which has usable chamber dimensions of 82 ft by 450 ft, has a lift of 88 ft with the normal upper pool elevation at 190 ft. The lock, along with a 9 ft-deep, 200 ft-wide navigation channel extending to Columbus, Georgia, is authorized for navigation use.

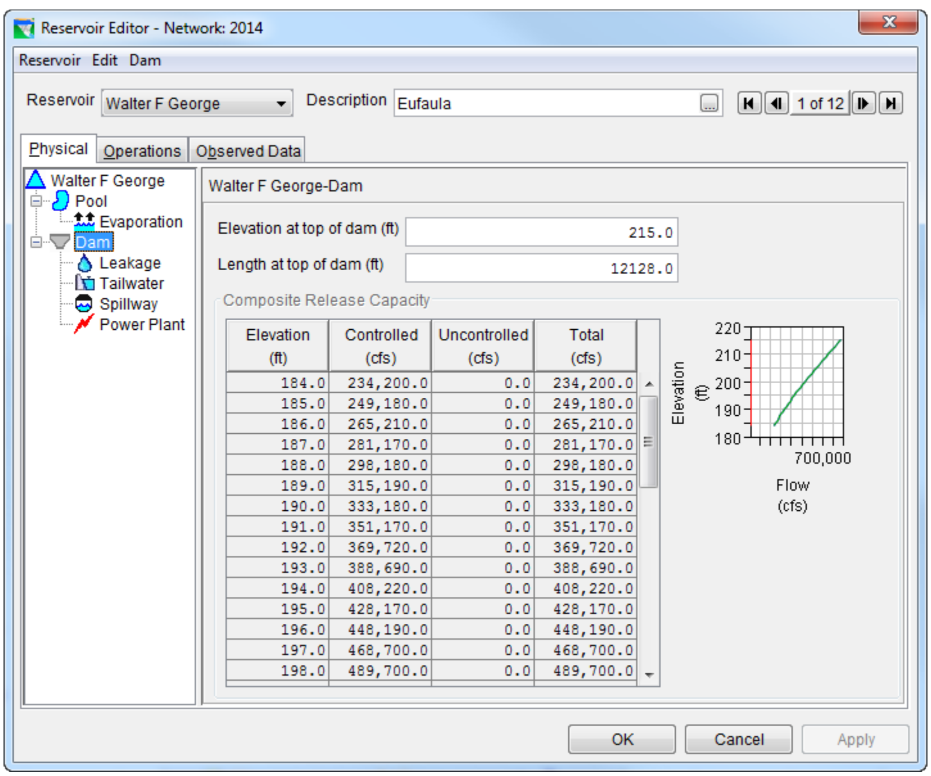
Walter F. George Lake is the largest reservoir in the ACF Basin; it has a surface area of 45,180 acres at elevation 190 ft, the top of the conservation pool (June through September). The top of the conservation pool is set at 188 ft during the winter and early spring months (December through April). The bottom of the conservation pool is at 184 ft. At the full pool elevation of 190 ft, the reservoir provides a total storage of 934,400 ac-ft, of which 244,400 ac-ft is conservation storage and 690,000 ac-ft is inactive storage. There is no dedicated flood storage at this project.

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the HEC-ResSim model. The *elevation-storage-area* defines the pool as shown in Figure C.03. The 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 as shown in Figure C.04, and the Dam reflects the composite release capacity of all of the outlets.



Elevation (ft)	Storage (ac-ft)	Area (acre)
100.00	0.00	0.00
110.00	2610.00	587.00
120.00	11680.00	1248.00
125.00	18670.00	1550.00
130.00	27240.00	1894.00
135.00	37920.00	2375.00
140.00	51210.00	2966.00
145.00	67830.00	3720.00
150.00	89100.00	4895.00
155.00	118100.00	6815.00
160.00	161500.00	10624.00
163.00	196700.00	12815.00
165.00	224000.00	14501.00
170.00	308700.00	19457.00
175.00	419000.00	24556.00
180.00	556300.00	30557.00
181.00	587600.00	31897.00
182.00	620200.00	33396.00
183.00	654400.00	34880.00

Figure C.03 Reservoir Editor – Network 2014 : Physical Tab -- Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
184.0	234,200.0	0.0	234,200.0
185.0	249,180.0	0.0	249,180.0
186.0	265,210.0	0.0	265,210.0
187.0	281,170.0	0.0	281,170.0
188.0	298,180.0	0.0	298,180.0
189.0	315,190.0	0.0	315,190.0
190.0	333,180.0	0.0	333,180.0
191.0	351,170.0	0.0	351,170.0
192.0	369,720.0	0.0	369,720.0
193.0	388,690.0	0.0	388,690.0
194.0	408,220.0	0.0	408,220.0
195.0	428,170.0	0.0	428,170.0
196.0	448,190.0	0.0	448,190.0
197.0	468,700.0	0.0	468,700.0
198.0	489,700.0	0.0	489,700.0

Figure C.04 Reservoir Editor – Network 2014:Physical Tab -- Dam

III. NOAction Operations

The Corps operates this reservoir as a peaking facility with normal 5-day operation with the potential for weekend operation to coincide with customer schedules. The number of hours of generation per day depends on the available storage, system hydropower and navigation flow requirements, and other factors. The power installation at the lake has recently been rehabilitated in 2010. The installation consists of four generating units of 42 MW, for a total of 168 MW.

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 C.01 shows the definition of Walter F. George's "NO-Action" operational zones, which consist of zones of flood control and conservation.

Table C.01 Zone Elevations for "NO-Action" Operation Set

Walter F George	NO-Action Top of **Zone Elevation** Values (feet) Blue values = entered; Black *italic* values = assumed; Orange linear = linear-interpolated values									
Seasons =	**1-Jan**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Aug**	**1-Sep**	**1-Oct**	**1-Nov**	**1-Dec**
Zones:										
Top of Dam	215	*215*	*215*	*215*	*215*	*215*	*215*	*215*	*215*	*215*
Max Flood	199	*199*	*199*	*199*	*199*	*199*	*199*	*199*	*199*	*199*
Flood Control	190	*190*	*190*	*190*	*190*	*190*	*190*	*190*	*190*	*190*
Conservation	188	*188*	*188*	188	190	*190*	*190*	190	linear	188
Zone 2	187.5	*187.5*	*187.5*	187.5	189	189	linear	187.5	*187.5*	*187.5*
Zone 3	185.5	185.5	186.3	187.1	188	188	linear	linear	linear	185.5
Zone 4	184.5	184.5	linear	187	linear	linear	185	184.88	184.75	184.62
Inactive	184	*184*	*184*	*184*	*184*	*184*	*184*	*184*	*184*	*184*

The top of the operation zones vary seasonally (as shown in Figure C.05). These zones are used in balancing the system through tandem operations to meet the ESA release requirements from Jim Woodruff. They are also used to define the composite action zones and track the active composite zone to determine flow releases together with basin inflow and operating seasons in accordance with the requirements in RIOP. The seasonal ordinates of the action zones are provided by the Mobile District.

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

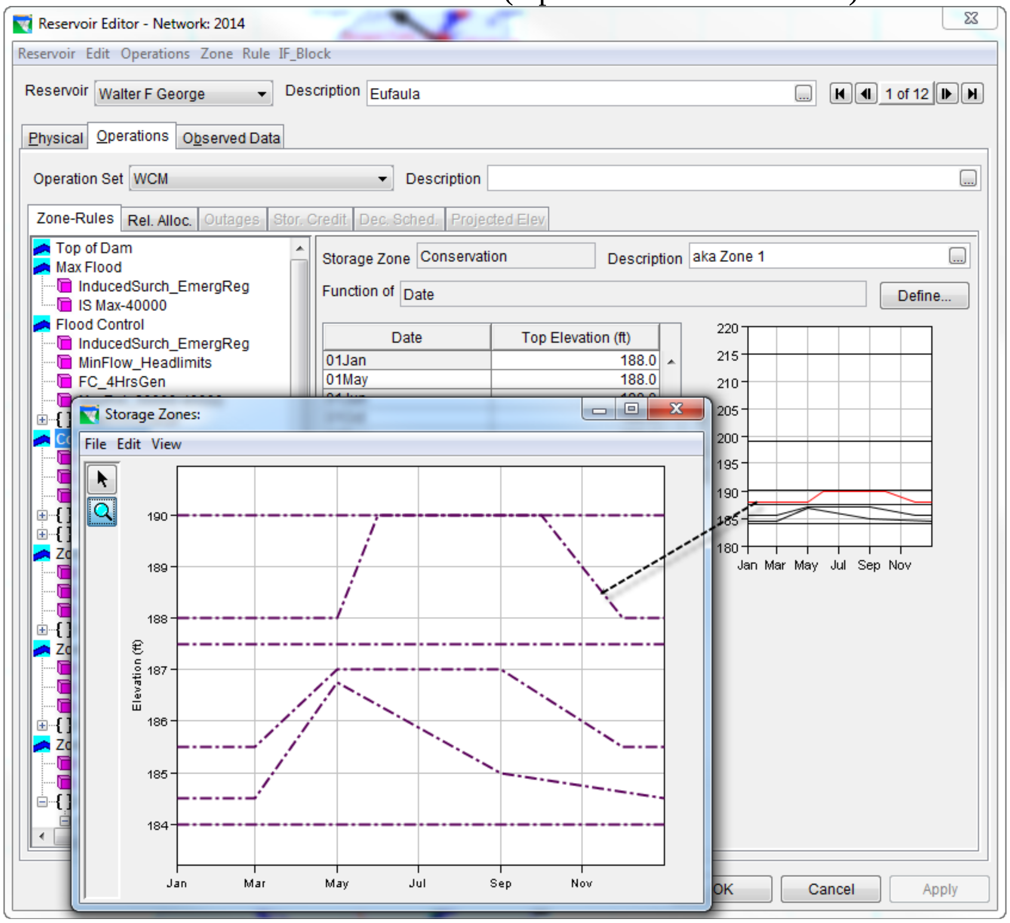


Figure C.05 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

Figure C.06 shows a sequential release allocation approach specified for available outlets along Walter F. George Dam. The available outlets are given an order of priority for release. The powerhouse gets the release first until it reaches release capacity. The spillway gets the remainder of the release.

Release Allocation:

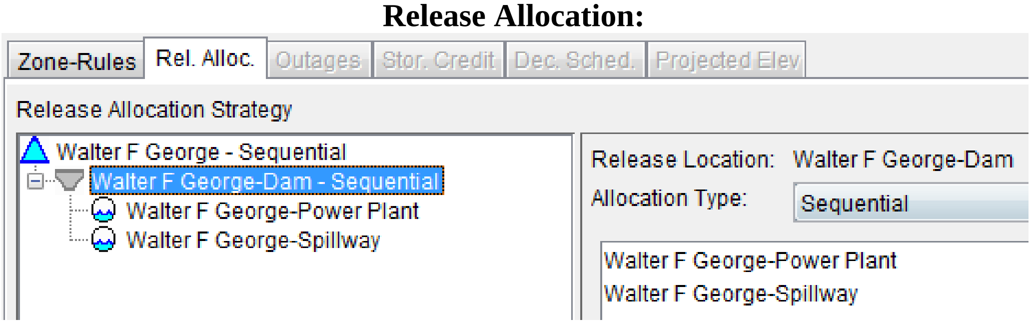


Figure C.06 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

Figure C.07 shows a set of operational rules specified for each zone that reflects the operation set named “NO-Action”.

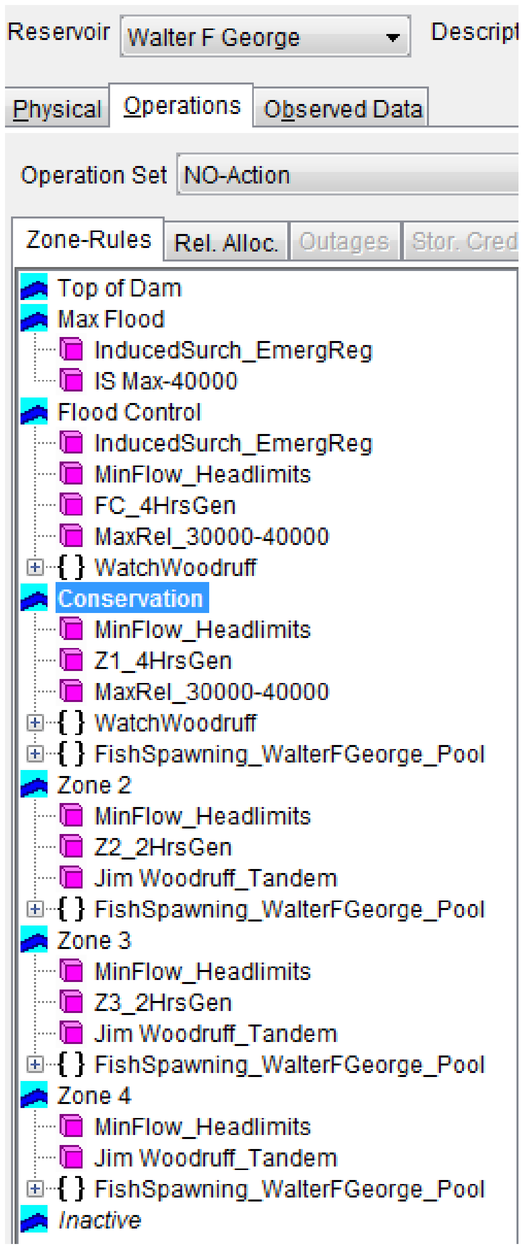


Figure C.07 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure C.08 through Figure C.12. The logic and purpose for each operational rule is described in Section C.

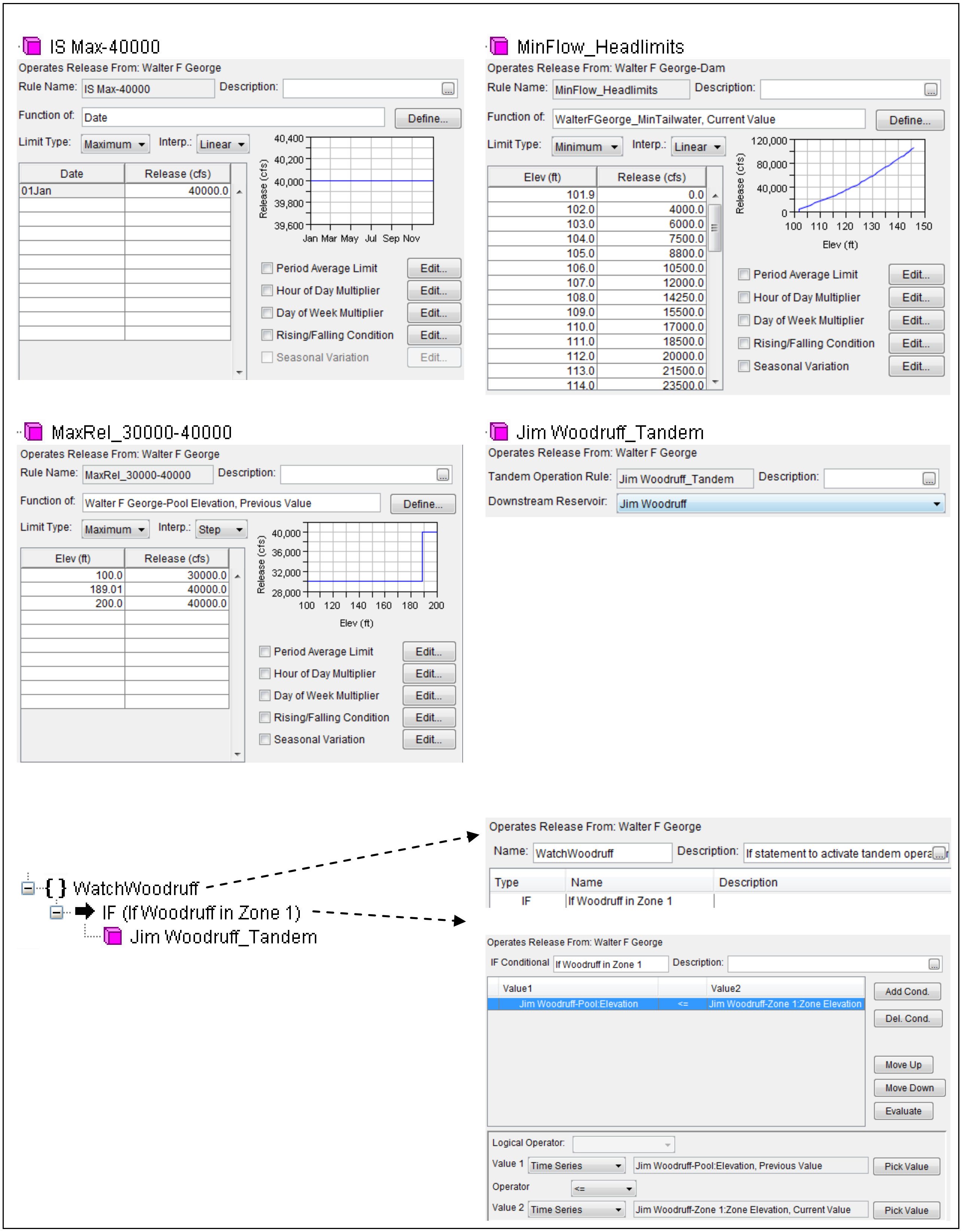
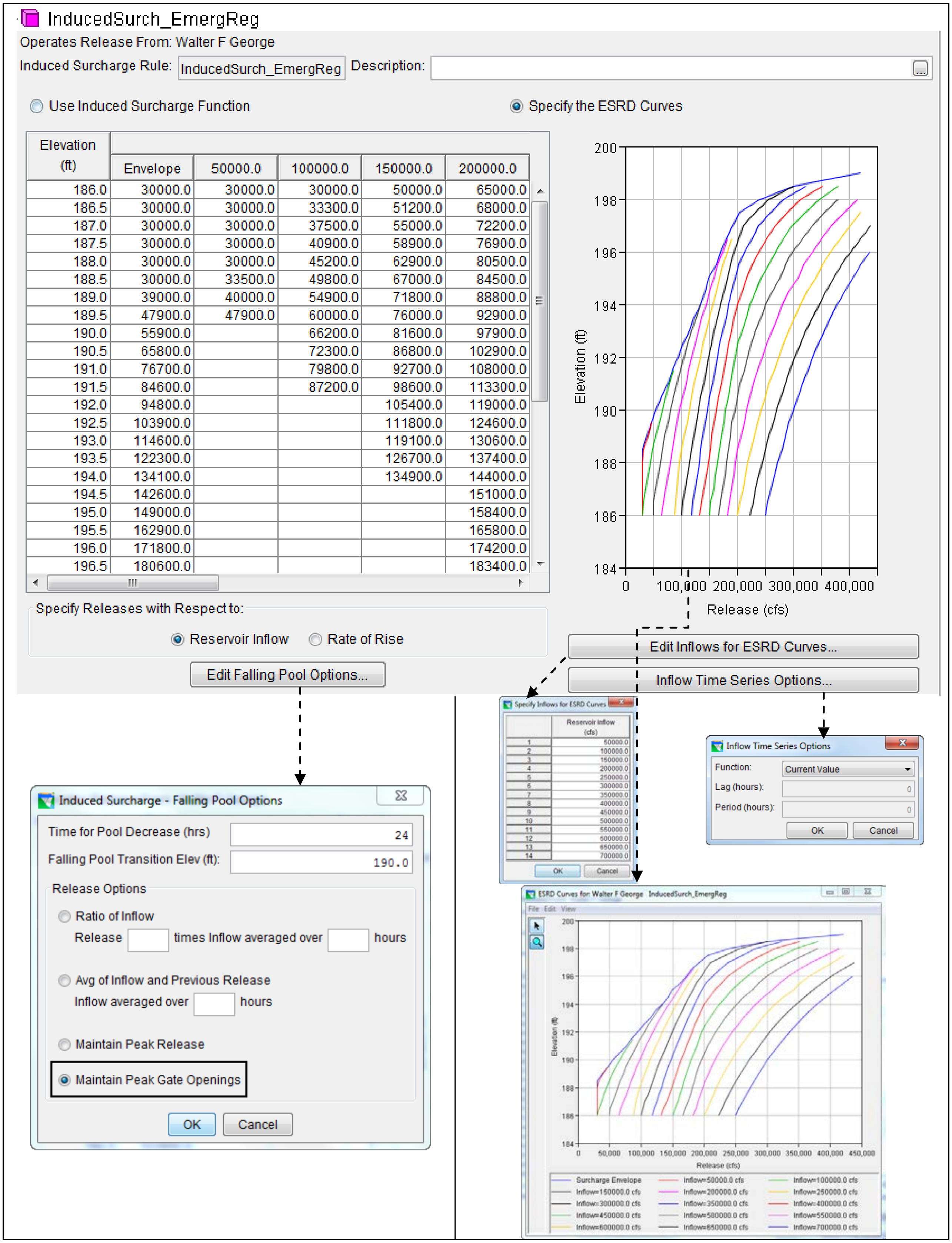


Figure C.08 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Max, Min, and Tandem Rules



Elevation (ft)	Envelope	50000.0	100000.0	150000.0	200000.0
186.0	30000.0	30000.0	30000.0	50000.0	65000.0
186.5	30000.0	30000.0	33300.0	51200.0	68000.0
187.0	30000.0	30000.0	37500.0	55000.0	72200.0
187.5	30000.0	30000.0	40900.0	58900.0	76900.0
188.0	30000.0	30000.0	45200.0	62900.0	80500.0
188.5	30000.0	33500.0	49800.0	67000.0	84500.0
189.0	39000.0	40000.0	54900.0	71800.0	88800.0
189.5	47900.0	47900.0	60000.0	76000.0	92900.0
190.0	55900.0		66200.0	81600.0	97900.0
190.5	65800.0		72300.0	86800.0	102900.0
191.0	76700.0		79800.0	92700.0	108000.0
191.5	84600.0		87200.0	98600.0	113300.0
192.0	94800.0			105400.0	119000.0
192.5	103900.0			111800.0	124600.0
193.0	114600.0			119100.0	130600.0
193.5	122300.0			126700.0	137400.0
194.0	134100.0			134900.0	144000.0
194.5	142600.0				151000.0
195.0	149000.0				158400.0
195.5	162900.0				165800.0
196.0	171800.0				174200.0
196.5	180600.0				183400.0

Figure C.09 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Induced Surcharge Rule

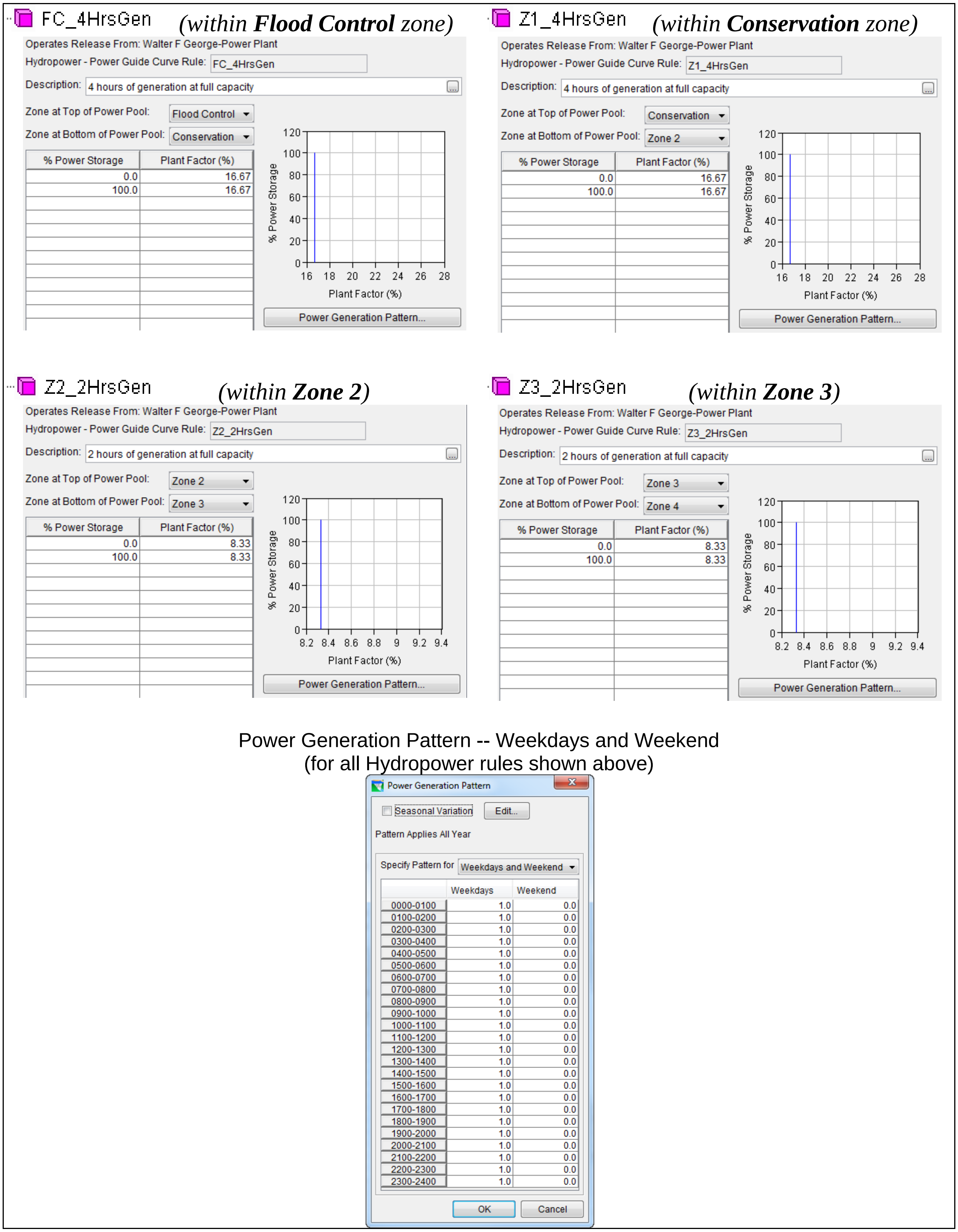


Figure C.10 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Hydropower Rules

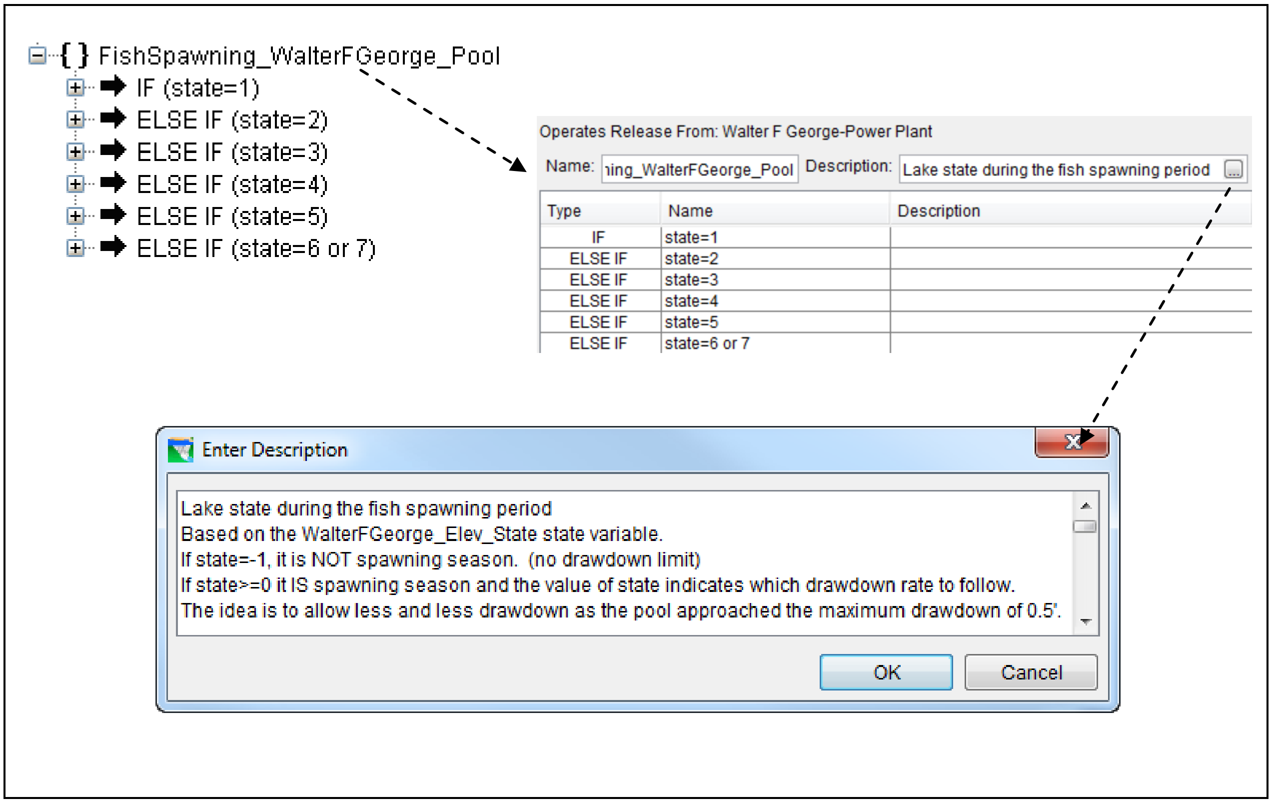


Figure C.11 Fish Spawning -- "Conditional Blocks"

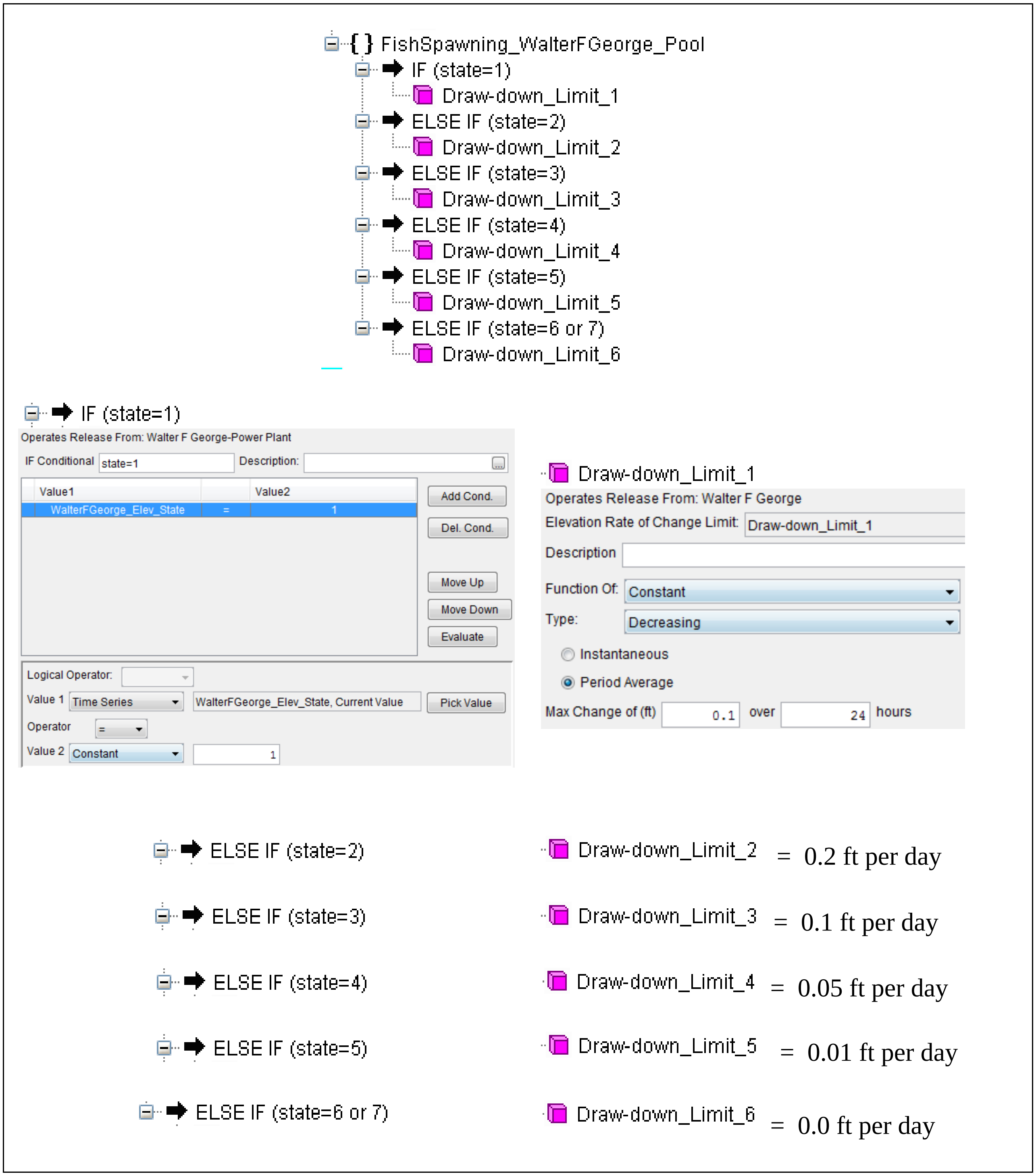


Figure C.12 Fish Spawning -- "IF-Blocks" and "Rules" and "WalterFGeorge_Elev_State" Values

C. Rule Descriptions

1. IS Max-40000

This rule (see Figure C.08) sets a maximum release (40,000 cfs) from Walter F. George when induced surcharge operations are not in effect. It is essential to enter this maximum flow limit to guide releases back towards flood control operations after induced surcharge operations finish.

2. MinFlow_Headlimits

This rule (see Figure C.08) represents the maximum head limit of 88 ft for Walter F. George Dam. A state variable, "WFGeorge_MinTailwater", is created to determine the minimum tailwater elevation at Walter F George based on the maximum head limit of 88 ft. Based on the pool elevation at the previous time step, the state variable script computes the minimum tailwater elevation for the current time step. In the ResSim model, the minimum tailwater elevation is converted to a discharge value based on the stage-discharge rating curve, and used as a minimum flow release from Walter F. George

3. MaxRel_30000-40000

This rule (see Figure C.08) sets a maximum release of 30,000 or 40,000 cfs, depending on pool elevations. From elevation 100.0 ft to 189.0 ft, the maximum release is 30,000 cfs. Above 189.0 ft, the maximum release is 40,000 cfs. The rule is used in both the flood control and conservation zones.

4. Jim Woodruff_Tandem

This rule (see Figure C.08) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F. George, and Lake Seminole to meet the Endangered Species Act (ESA) requirements on the Apalachicola River.

5. { } WatchWoodruff

This conditional logic (see Figure C.08) activates the tandem operation when the pool elevation at Lake Seminole is in Zone 1.

6. InducedSurch_EmergReg

This rule (see Figure C.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 releases to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. An induced surcharge rule requires an induced surcharge schedule, which is a family of curves of spillway discharges and pool elevations for a range of reservoir inflows. In the daily model, the inflow at the current time step is used. The induced surcharge schedule also includes an induced surcharge envelope curve that represents the maximum reservoir levels that would be permitted at various rates of spillway discharge when operating under the induced surcharge plan. The induced surcharge rule also includes falling pool options. The *Time for Pool Decrease* 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 is the pool elevation below which the induced surcharge rule will no longer operate. The *Release Options* assign the method for computing falling pool releases. For Walter F. George Dam, the option of *Maintain Peak Release* is selected.

7. FC_4HrsGen, Z1_4HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure C.10) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor, which is a function of storage and the requirement (4 or 2 hours of generation) varies by zones.

8. Fish Spawning_Walter F George

The IF-Blocks and rules (see Figure C.11 through Figure C.12) 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 March 15 through May 15 for Lake Eufaula, 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 G.

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 in as follows:

```
# State variable: WalterFGeorge_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
```

The state variable (“WalterFGeorge_Elev_State”) script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is described in Appendix G.

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 C.11 and Figure C.12). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure C.11 and Figure C.12):

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

IV. Alternative Operations

Walter F George Dam is one of the critical elements in the ACF system. In updating the Water Control Manual, Walter F George‘s action zones are revised to improve the management of the combined composite storages of Lake Lanier, West Point Lake, and Walter F. For the seven HEC-ResSim alternatives, Walter F George Reservoir used two operation sets. The operation sets used with each alternative are given in Table C.02. Table C.03 describes each operation set.

Table C.02 Alternatives, Operation Sets, and Reservoir Network Used at Walter F George

Alternative	Operation Set	Reservoir Network
NOAction	NO-Action	2014_Base
Alt1	NO-Action	2014
Alt2	Silver	2014
Alt3	Silver	2014
Alt4	Silver	2014
Alt5	Silver	2014
Alt6	Silver	2014
Alt7	Silver	2014

Table C.03 Operation Sets Used at Walter F George

Operation Set	**Description**
NO-Action	Current operation / no action. Uses Network "2014".
Silver	Same as NO-Action operation set except Silver uses **Revised Action Zones.**

A. Silver Operation Set

Silver operation set for Walter F George retains all the rules and settings from NO-Action operation set except this operation set uses different elevation of action zones labeled as *Revised* Action Zones.

1. Revised Action Zones

Differences in settings in the Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. Walter F George's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised Action Zones are shown in Table C.04, and the comparison to the action zones in NO-Action operation set is shown in Figure C.13.

Table C.04 *Revised* Action Zone Elevations for Silver Operation Set at Walter F George

Zones	**1-Jan**	**1-Mar**	**1-May**	**1-Jun**	**1-Sep**	**1-Oct**	**1-Dec**
Top of Dam	215						
Max Flood	199						
Flood Control	190						
Conservation	188		188	190		190	188
Zone 2	187.5						
Zone 3	185.5	185.5	187		187		185.5
Zone 4	184.5	184.5	186.75		185		
Inactive	184						

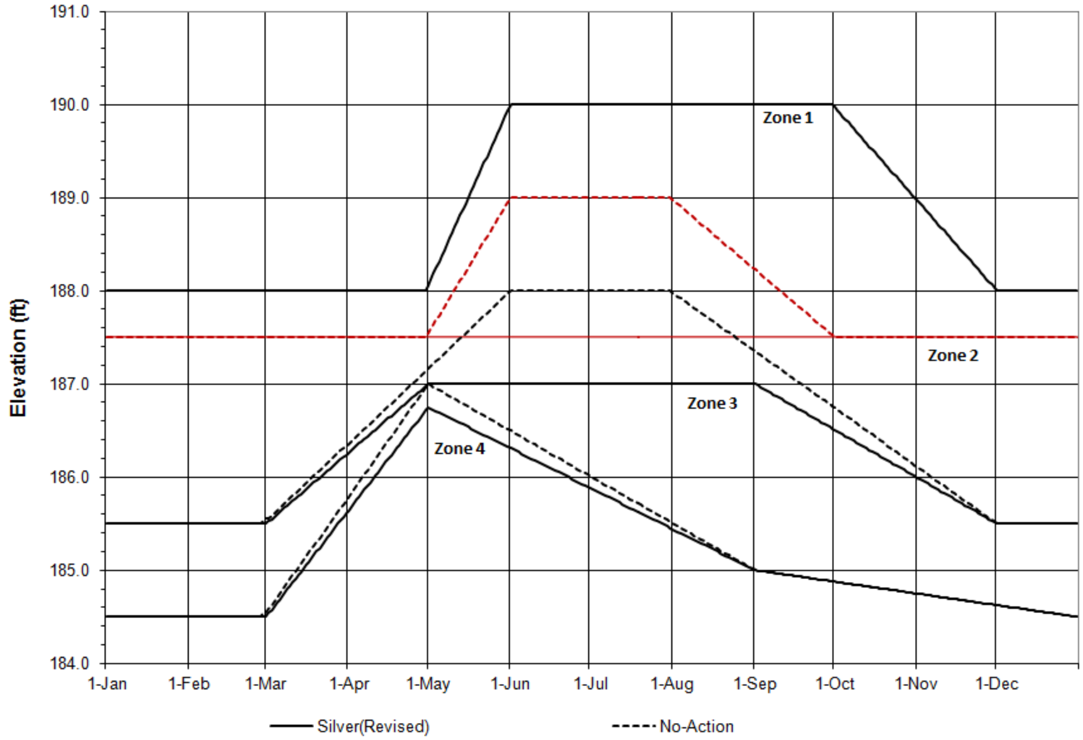


Figure C.13 Comparison of NO-Action and *Revised* Action Zones at Walter F. George

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix D – George Andrews

June 2014

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Appendix D – George Andrews

Table of Contents:

List of Tables:

List of Figures:

George Andrews

I. Overview

The George W. Andrews Lock and Dam is located on the lower Chattahoochee River between Walter F. George Dam and Jim Woodruff Dam. George Andrews operates to provide navigational depths upstream to Walter F. George, and to reregulate the outflow from peaking power operations at Walter F. George. There is a maximum head limit of 25 feet at George Andrews Dam. Because George Andrews Reservoir has very limited storage, it is essentially a run-of-the-river project. Therefore, the George Andrews project is represented in the daily ResSim model as a *flow-through* situation project.

Figure D.01 shows the location of George Andrews Dam and its pool as it is represented in the HEC-ResSim model.

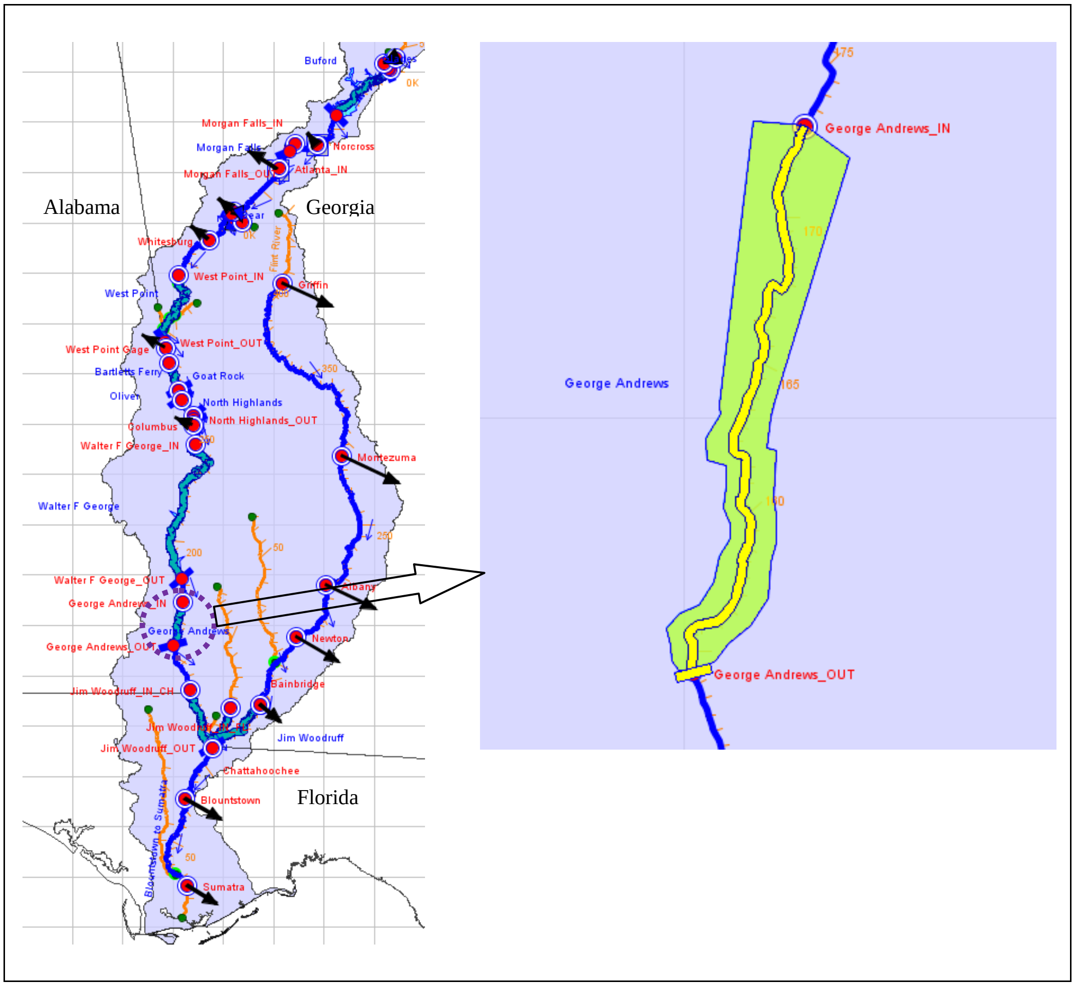

Figure D.01 HEC-ResSim Map Display Showing Location of George Andrews

Figure D.02 shows a photo of George Andrews Dam.

Figure D.02 Photo of George Andrews Lock and Dam

II. Physical Characteristics

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the ResSim model. The *elevation-storage-area* defines the pool (Figure D.03). The dam consists of only one type of controlled outlet: a gated spillway (Figure D.04).

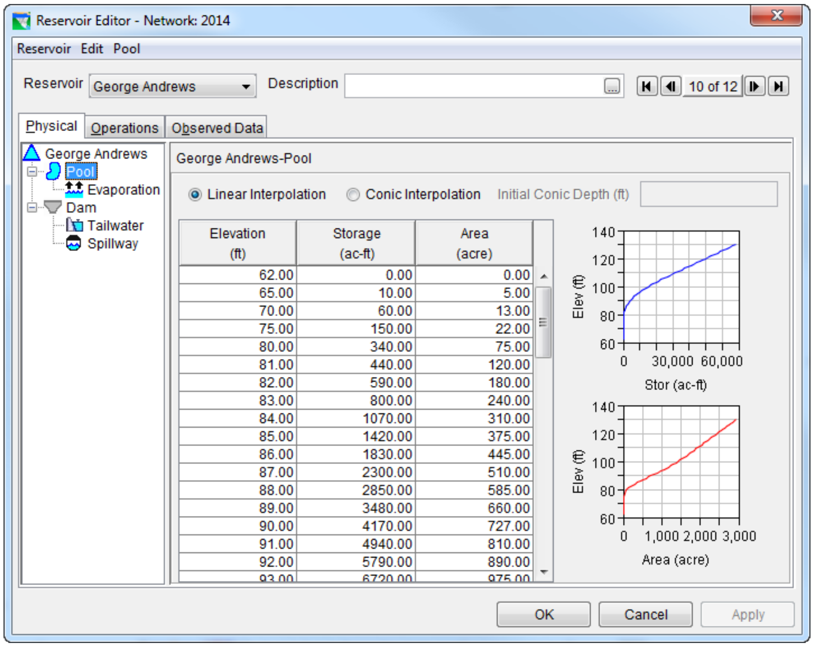

Figure D.03 Reservoir Editor – Network 2014: Physical Tab -- Pool

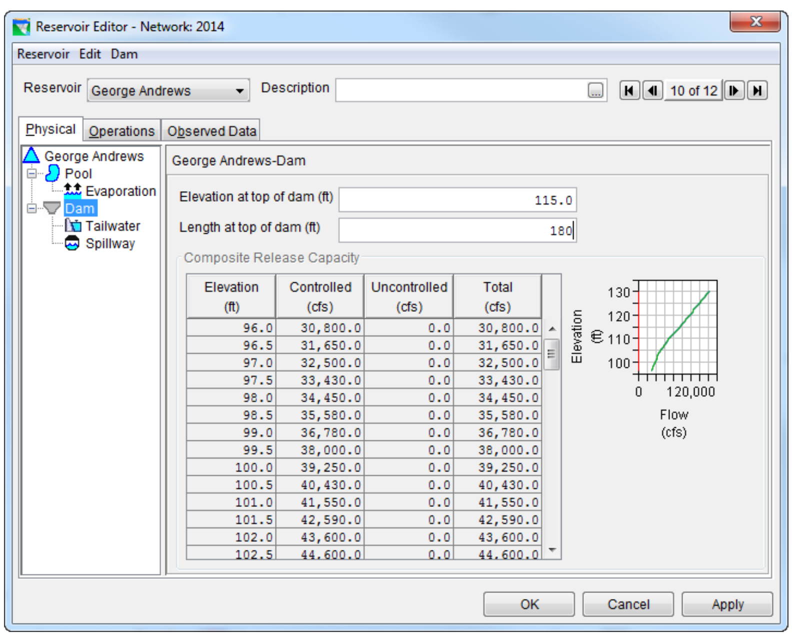

Figure D.04 Reservoir Editor – Network 2014: Physical Tab – Dam

III. NOAction Operations

A. *Flow-thru* 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 George Andrew's *Flow-thru* operational zones, which consist of zones of flood control and conservation.

Table D.01 Zone Elevations for *Flow-thru* Operation Set

George Andrews	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Flood Control	103
Conservation	102
Operating Inactive	96
Inactive	82

Figure D.05 and Figure D.06 show that George Andrews is modeled as a *flow-though* project without any operation rules. It essentially passes inflows.

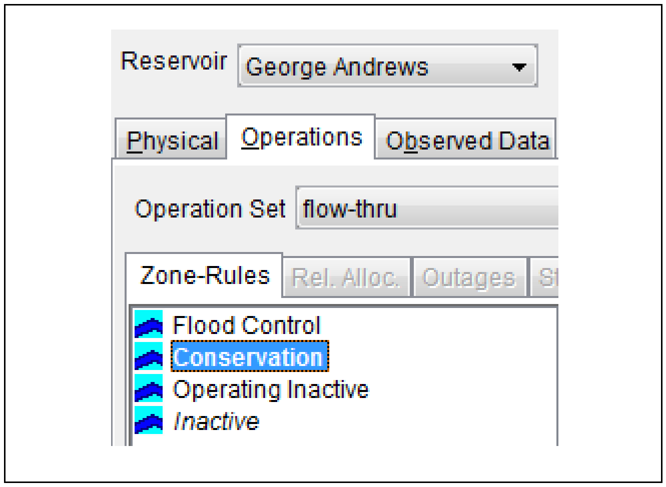

Figure D.05 Operations Tab – *Flow-thru* Zones

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

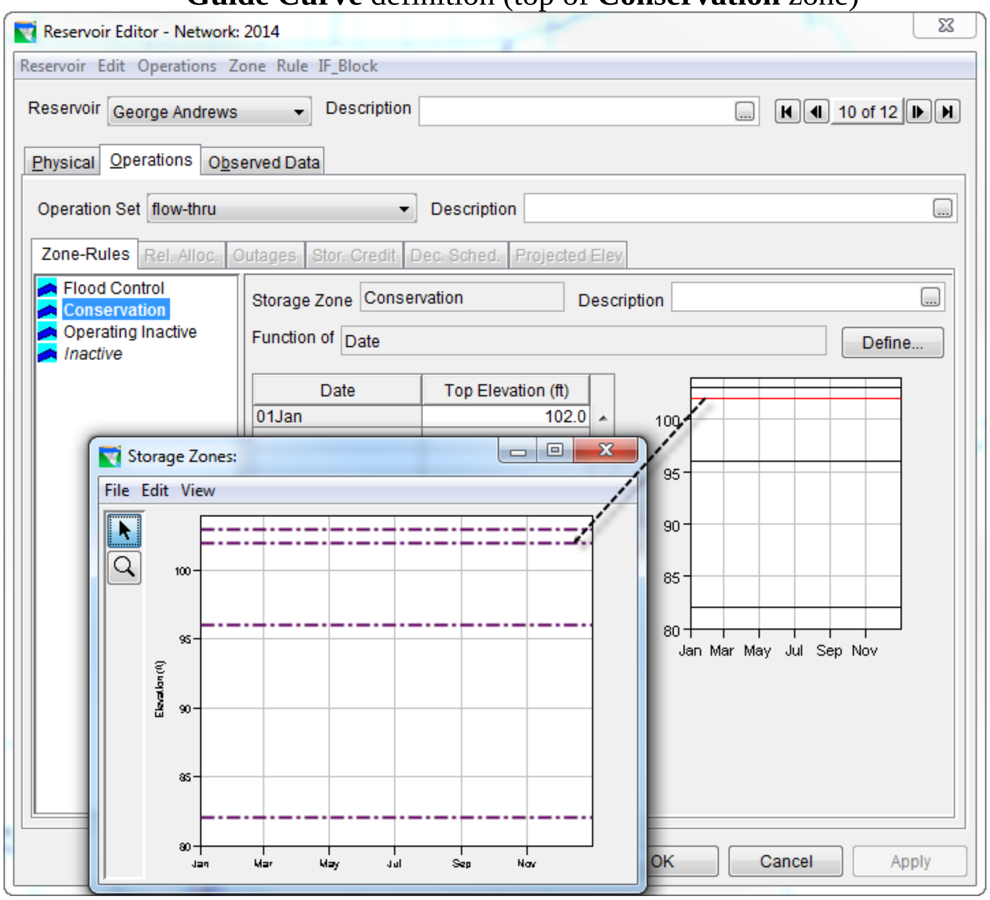

Figure D.06 Reservoir Editor: Operations Tab – *Flow-thru* OpSet – Guide Curve

IV. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for George Andrews is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix E – Jim Woodruff (Lake Seminole)

June 2014

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Appendix E – Jim Woodruff

Table of Contents:

List of Tables:

List of Figures:

Appendix E – Jim Woodruff

Jim Woodruff (Lake Seminole)

I. Overview

Jim Woodruff Lock and Dam is a multi-purpose project created primarily to aid navigation in the Apalachicola River below the dam and in the Chattahoochee and Flint Rivers above the dam. The Mobile District of the Corps of Engineers operates the project for the primary purposes of navigation and hydroelectric power generation and secondary benefits such as public recreation, regulation of streamflow, and fish and wildlife conservation. Because Jim Woodruff is the most downstream project in the ACF basin and due to the fact that Lake Seminole has limited storage, it is essentially a run-of-river project, which depends largely on inflows controlled by upstream reservoirs. As a result, the output of the power plant varies with changes in the inflow entering Lake Seminole. Lake Seminole's limited storage is capable of short duration flow augmentation in the downstream Apalachicola River for navigation purposes, but for the most part, it is used to reregulate the weekday releases from Walter F. George Reservoir to provide a 7-day steady outflow from Lake Seminole.

The lock and spillway have a maximum head limit due to structural stability. In addition, the Jim Woodruff project complies with a number of very significant and complex environmental requirements, including actions contained in the Revised Interim Operations Plan (RIOP) at Jim Woodruff Dam, Gulf Sturgeon Spawning Operational Consideration, and Fish Spawning Operational Consideration for Lake Seminole and the Apalachicola River. These operational requirements often trigger system operations to use storages on a basin-wide basis.

Figure E.01 shows the location of Jim Woodruff Lock and Dam and its pool (Lake Seminole) as it is represented in the HEC-ResSim model, and Figure E.02 shows a photo of Jim Woodruff Lock and Dam.

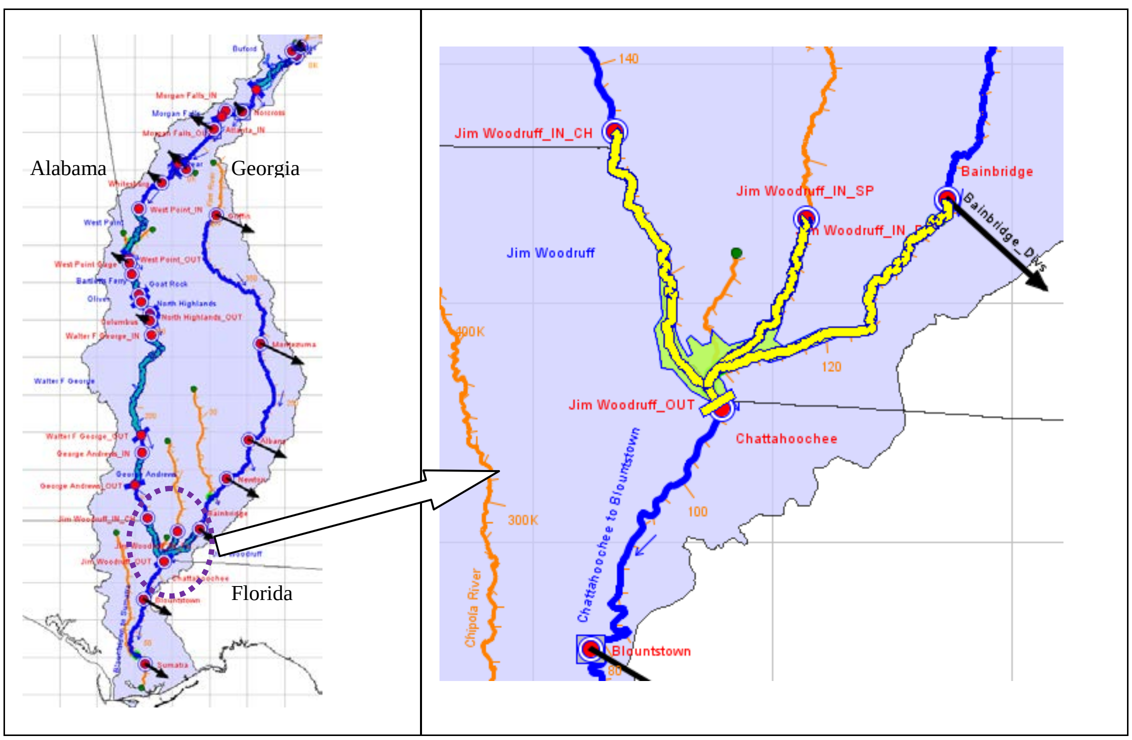


Figure E.01 HEC-ResSim Map Display Showing Location of Jim Woodruff

Figure E.02 Photo of Jim Woodruff Lock and Dam

II. Physical Characteristics

The Jim Woodruff Lock and Dam are located on the Apalachicola River, 107.6 miles above its mouth, about 1,000 ft below the confluence of the Chattahoochee and Flint Rivers and 1.5 miles northwest of Chattahoochee, Florida. The reservoir, Lake Seminole, extends about 46.5 miles upstream along the Chattahoochee River to the vicinity of Columbia, Alabama, and about 47 miles upstream along the Flint River, or 17 miles above Bainbridge, Georgia.

The existing project provides for a concrete open-crest spillway 1,634 ft long on the right bank, with crest at elevation 79 ft constituting a portion of the dam. The single-lift lock has usable chamber dimensions of 82 ft by 450 ft, with a maximum lift of 33 ft and a depth over the sills of 14 ft. The overflow dike section is 2,130 ft long on the left bank, with crest at elevation 85 ft. The gated spillway is 766 ft long with 16 gates that are 40 ft wide by 30.5 ft high.

The powerhouse contains an intake section constituting a portion of the dam. Next to the powerhouse is the switchyard and substation. The power installation consists of three units of 14.45 MW, or a total of 43.35 MW. The reservoir level is normally maintained near elevation 77 ft, giving the reservoir a total capacity of 367,320 ac-ft and a surface area of 37,500 acres. Storage of 0.5 ft above and below that elevation is used to reregulate flows into the reservoir from upstream projects that operate as peaking plants. Because no flood damage reduction storage is at this project, the reservoir level is maintained at elevation 77 ft by passing inflows through the spillway gates or through the powerhouse.

The physical characteristics of the reservoir are separated between the *Pool* and the *Dam* in the ResSim model. The *elevation-storage-area* defines the pool as shown in Figure E.03. The dam consists of three types of outlets: (1) a power plant, (2) a gated spillway, and (3) an emergency uncontrolled spillway. Each of these outlets is defined in the model as shown in Figure E.04, and the Dam reflects the composite release capacity of all of the outlets.

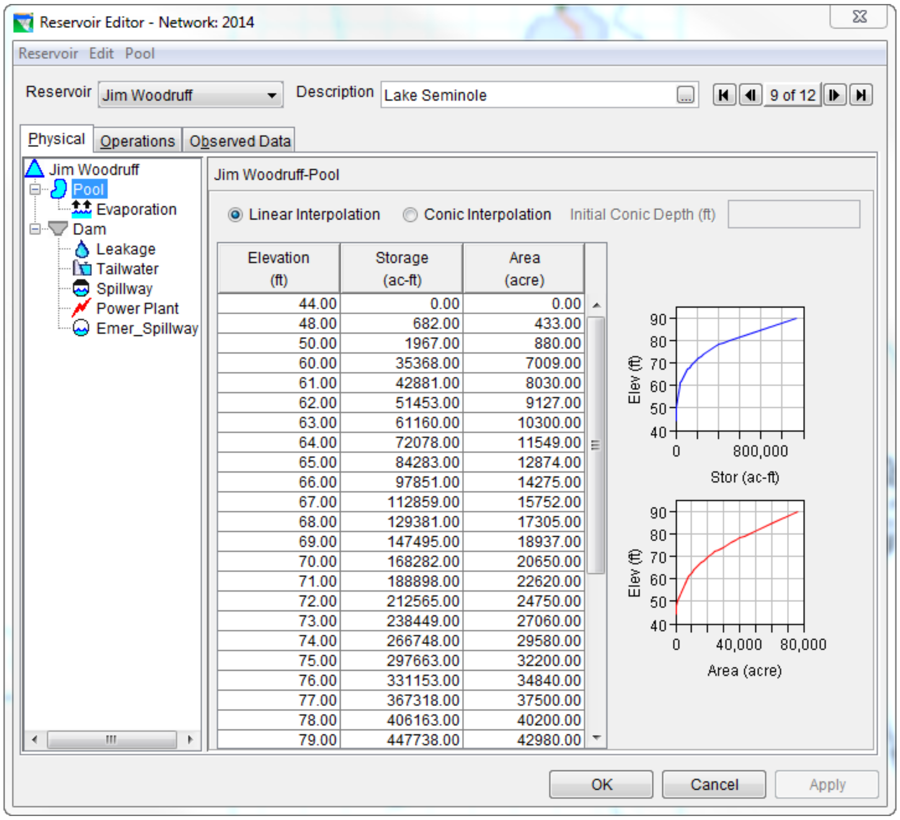


Figure E.03 Reservoir Editor- Network 2014:Physical Tab -- pool

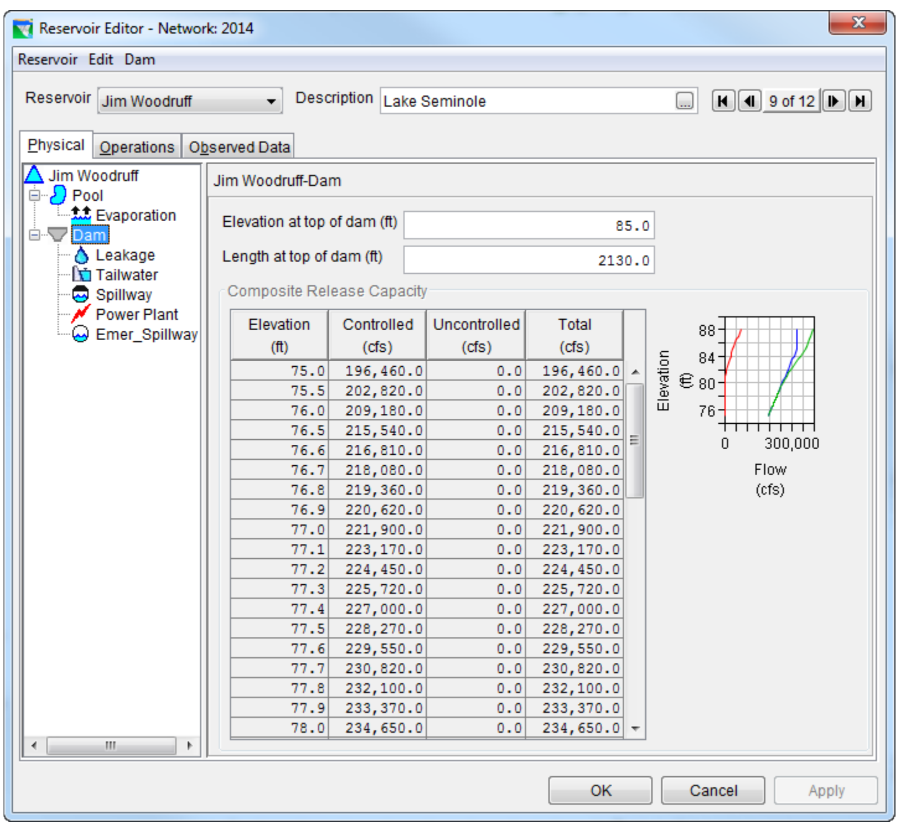


Figure E.04 Reservoir Editor- Network 2014:Physical Tab -- Dam

III. Action Operations

Jim Woodruff Reservoir settings include specifications for fish spawning standard operating procedures, Revised Interim Operations Plan (RIOP) for flow target and navigation operations. The RIOP was set up such that the measures for operation for flow target were coupled with measures for drought contingencies due to the impact of low flow conditions on both operations. It incorporates a drought contingency operation that specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage in the basin is replenished to a level that can support them.

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 operational zones defined for Jim Woodruff under the "NO-Action" operation set.

Table E.01 Zone Elevations for "NO-Action" Operation Set

Jim Woodruff	**NO-Action** Top of **Zone Elevation** Values (feet) Blue values = entered; Black *italic* values = assumed; Orange linear = linear-interpolated values				
Seasons =	**1-Jan**	**28-Feb**	**1-Mar**	**1-Jun**	**2-Jun**
Zones					
Top of Dam	85	*85*	*85*	*85*	*85*
Flood Control	79.89	*79.89*	*79.89*	*79.89*	*79.89*
Conservation	77.8	*77.8*	*77.8*	*77.8*	*77.8*
Zone 1	76.7	76.7	77.8	77.8	76.7
Zone 2	76.5	*76.5*	*76.5*	*76.5*	*76.5*
Zone 3	76.3	*76.3*	*76.3*	*76.3*	*76.3*
Zone 4	75.9	*75.9*	*75.9*	*75.9*	*75.9*
Inactive	75.5	*75.5*	*75.5*	*75.5*	*75.5*

The top of operation zone 1 varies seasonally (as shown in Figure E.05). These operation zones (or called action zones) are used in balancing the system through tandem operations to meet the ESA release requirements from Jim Woodruff. They are also used to define the composite action zones and track the active composite zone to determine flow releases together with basin inflow and operating seasons in accordance with the requirements in RIOP 2012. The seasonal ordinates of action zone 1 are provided by the Mobile District.

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

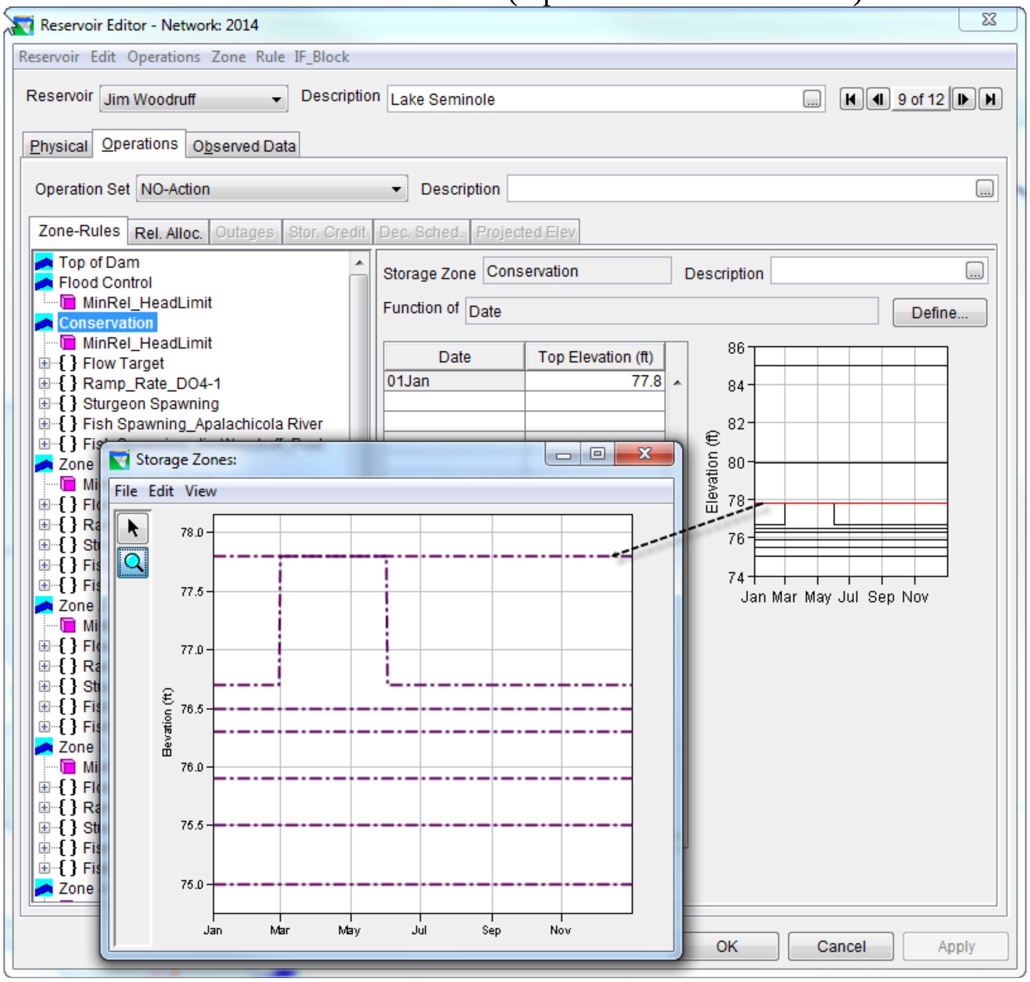


Figure E.05 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

Figure E.06 shows a sequential release allocation approach specified for available controlled outlets along Jim Woodruff 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 gated spillway then gets the remainder of the release.

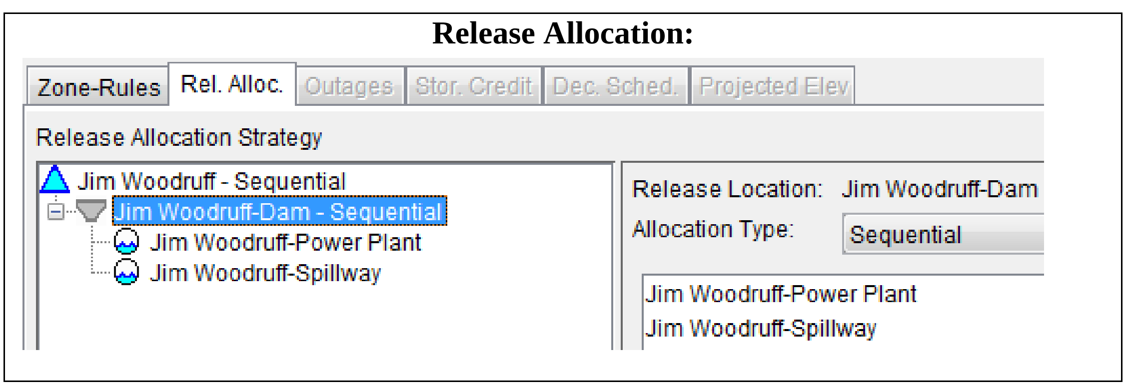


Figure E.06 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

Figure E.07 shows a set of operational rules specified for each zone that reflects the operation set named “NO-Action”.

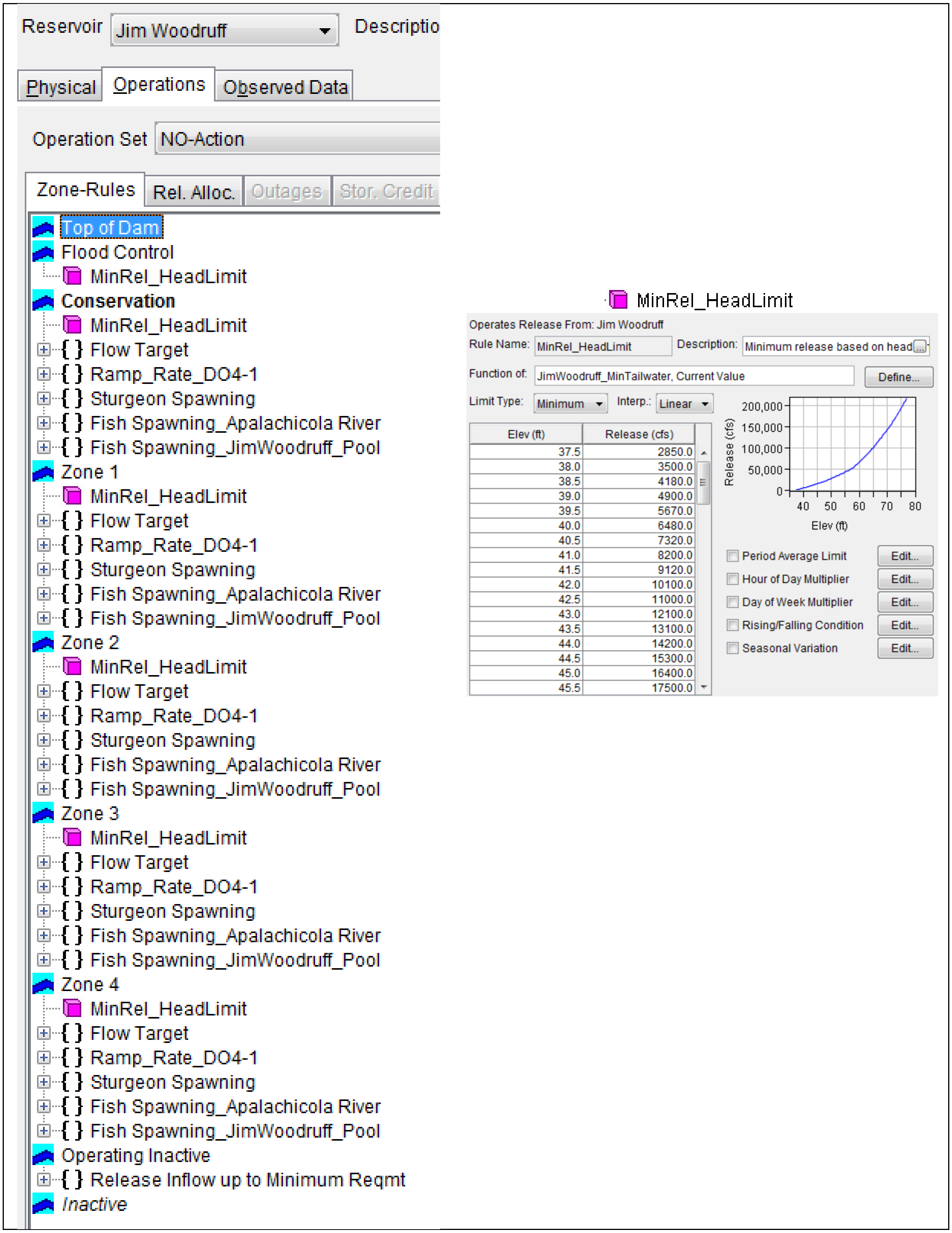
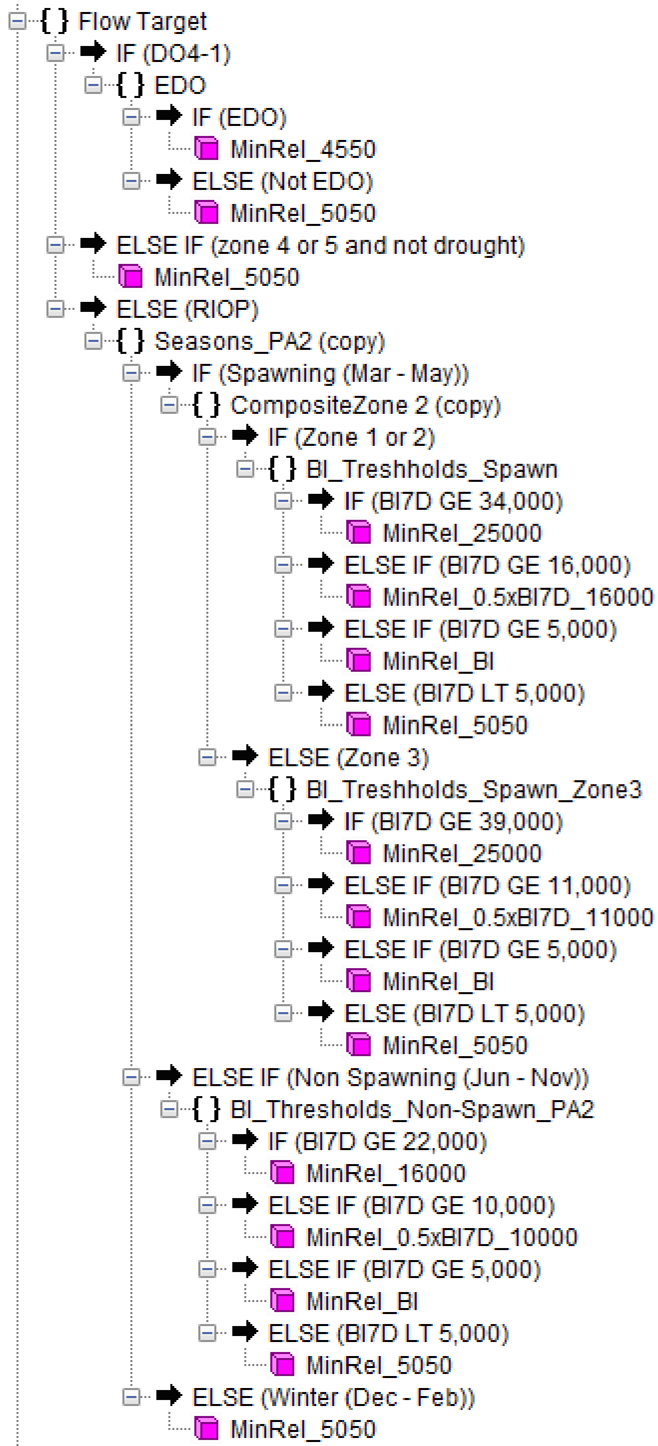


Figure E.07 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure E.07 through Figure E.18. The logic and purpose for each operational rule is described in Section C.



See Figures E.09 thru E.12 for “details” of the “Flow Target” conditional rule set

Figure E.08 NO-Action OpSet – Flow Target Conditional Rule Set

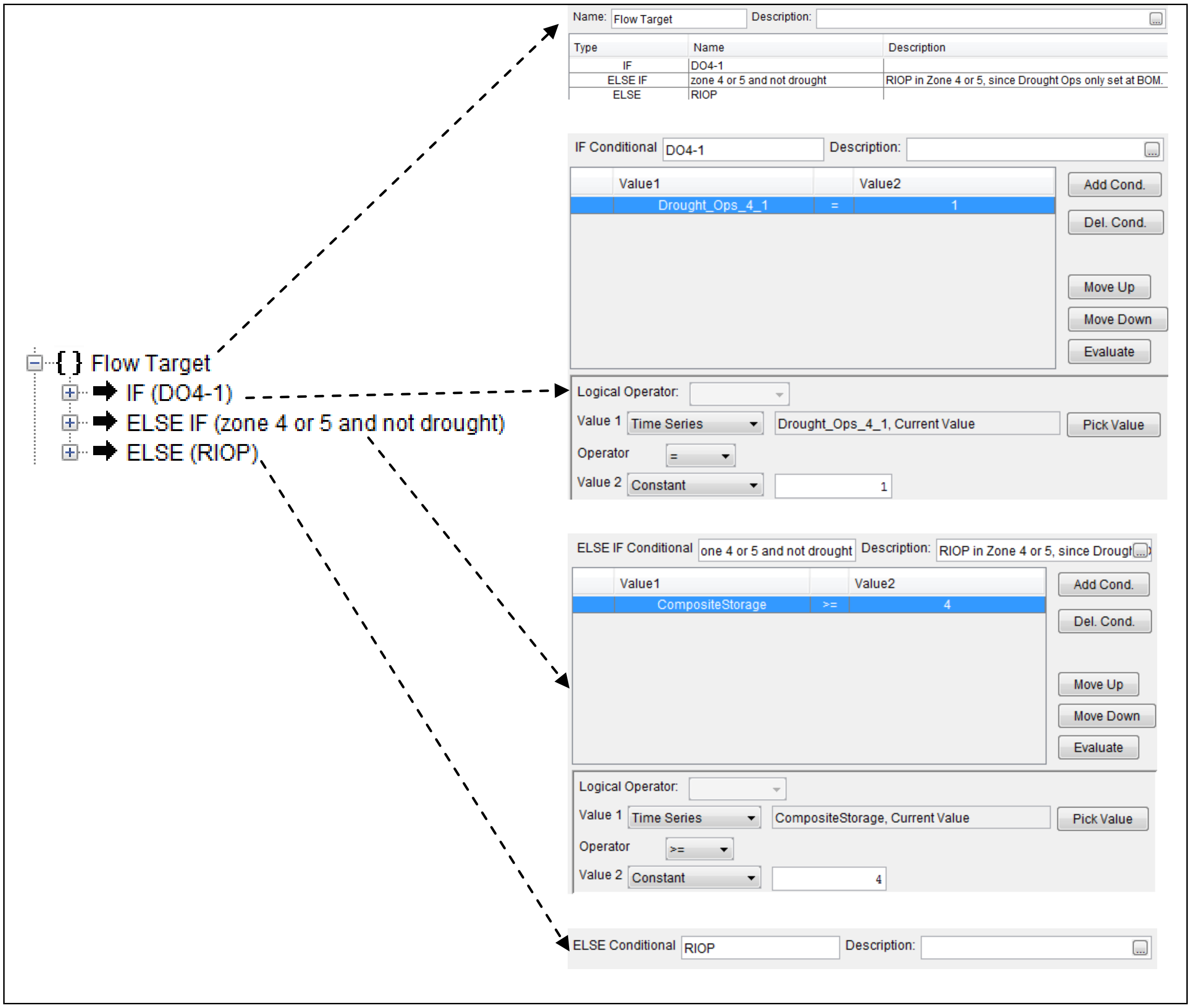


Figure E.09 Flow Target *(Part 1 of 4)*: Overview of " IF (DO4-1) - Else IF (Zone 4 or 5 and not drought) -Else (RIOP)"

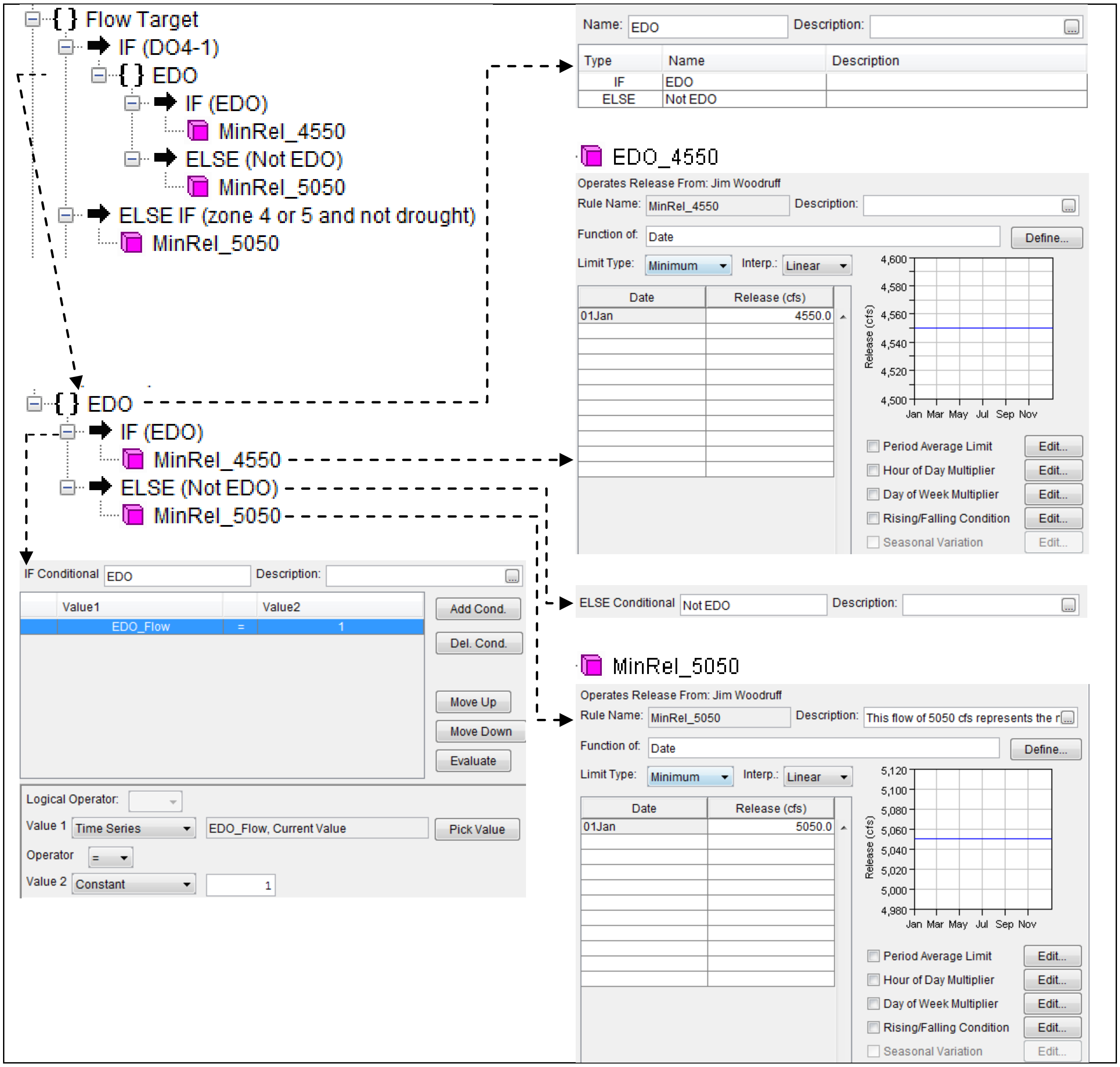


Figure E.10 Flow Target *(Part 2 of 4)*: Drought Operations ,Checking for "EDO" , "MinRel_4550"and Not EDO, "MinRel_5050"

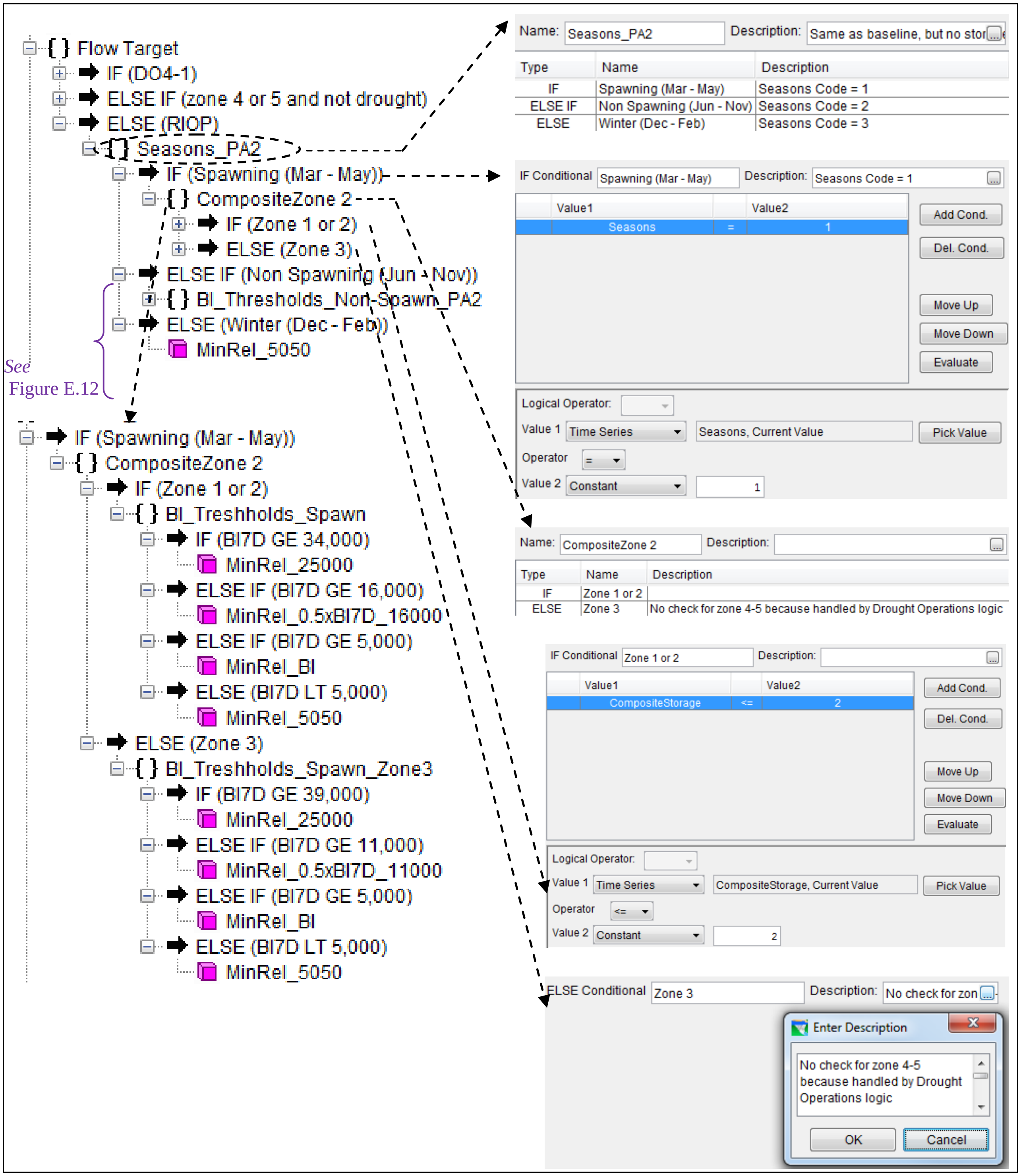


Figure E.11 Flow Target *(Part 3 of 4)*: Seasons – *Part 1 of 2* – "Overview" and check for "Spawning (Mar-May)"

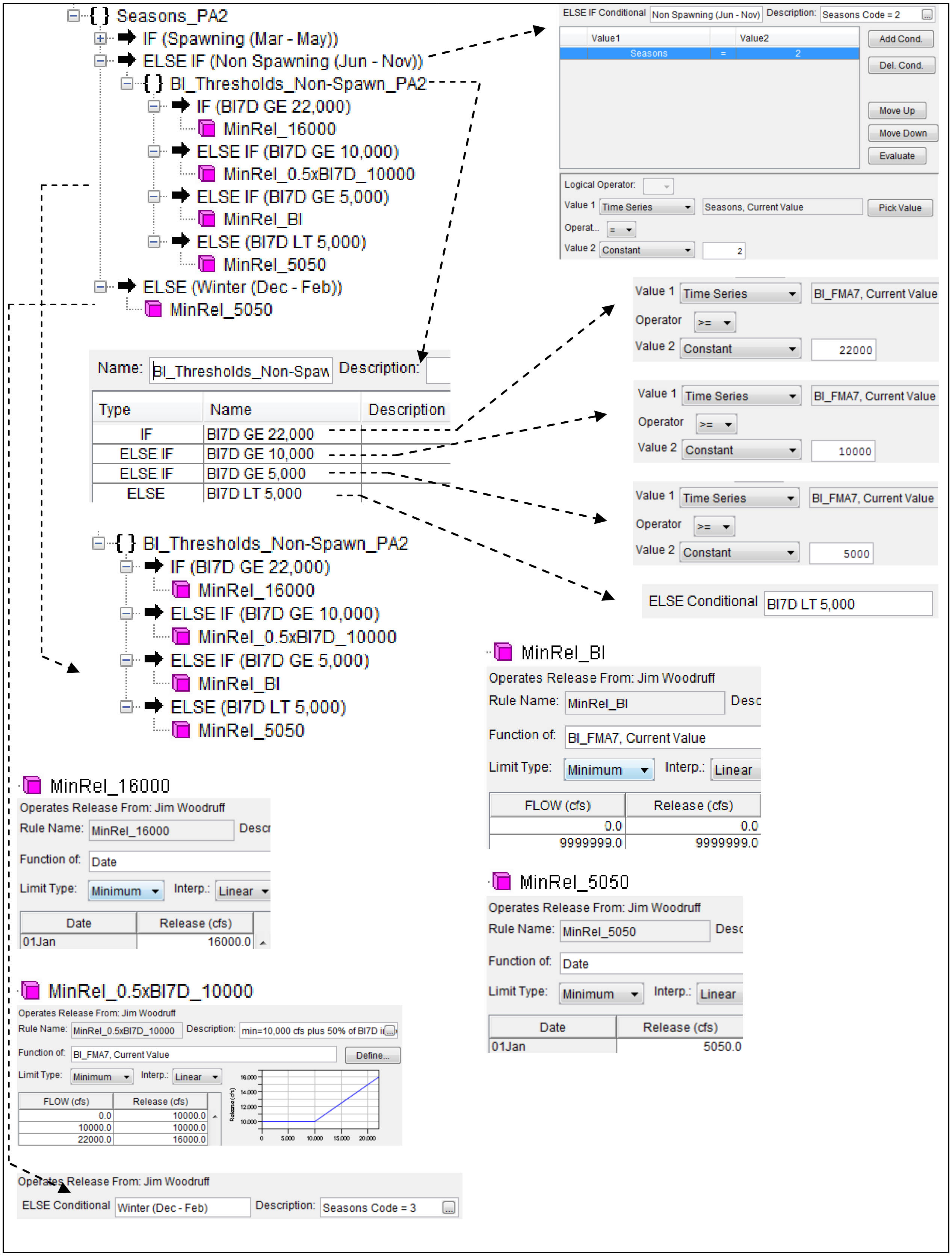


Figure E.12 Flow Target *(Part 4 of 4)*: Seasons – *Part 2 of 2* – Check for "Non Spawning (Jun-Nov)"

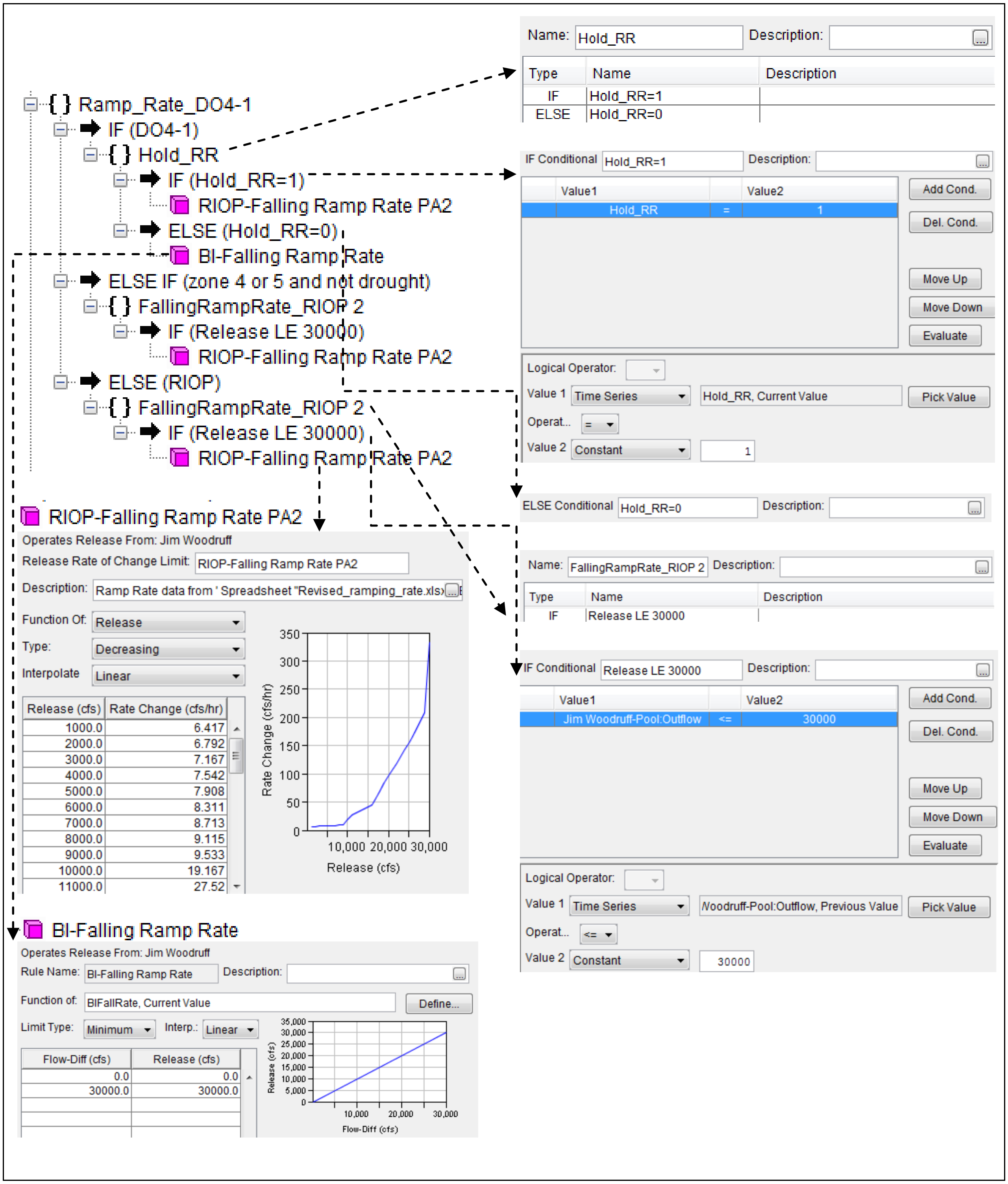


Figure E.13 Ramp_Rate_DO4-1 ("RIOP-Falling Ramp Rate" or "BI-Falling Ramp Rate")

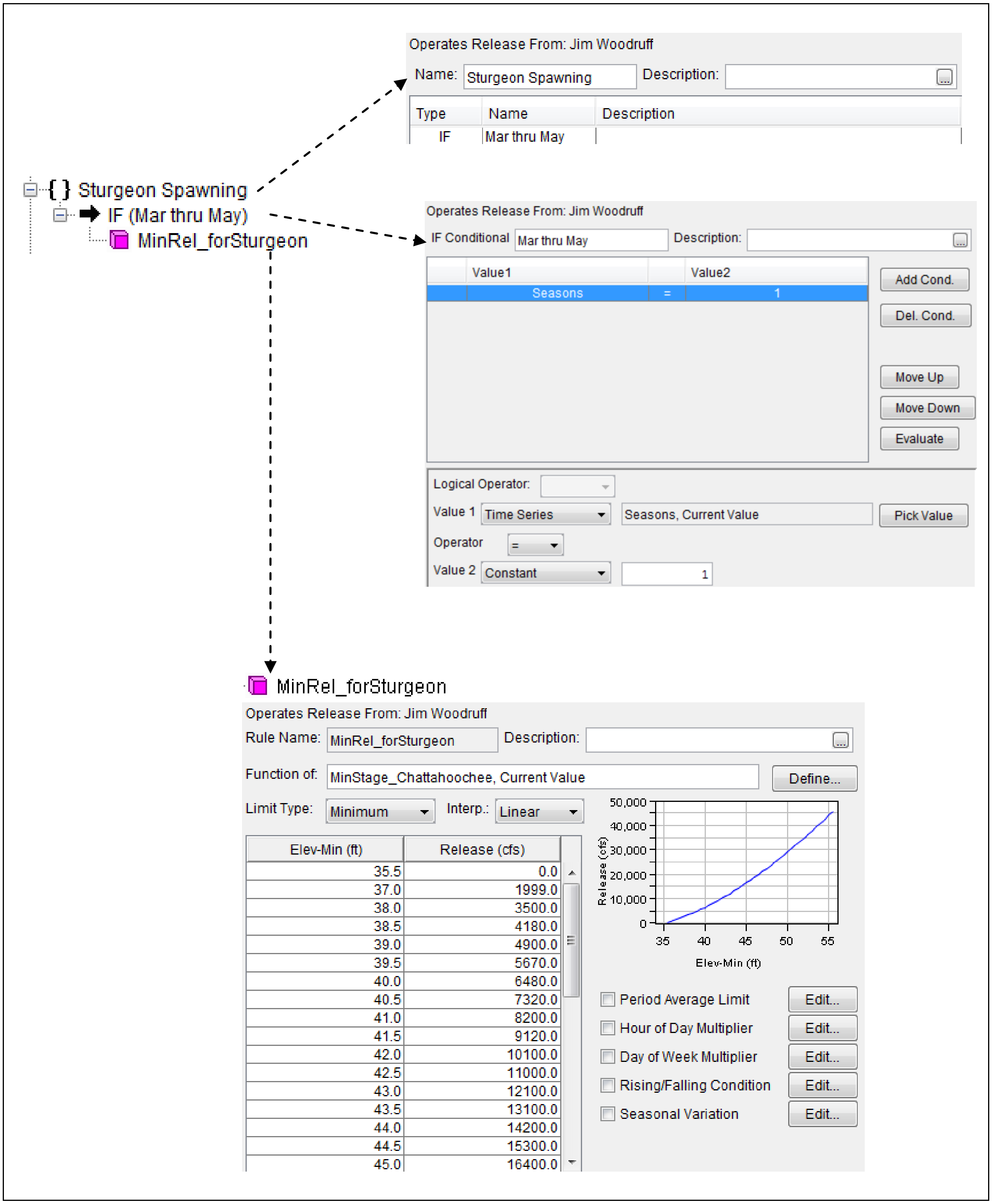


Figure E.14 Sturgeon Spawning -- "Conditional Blocks" and Rule

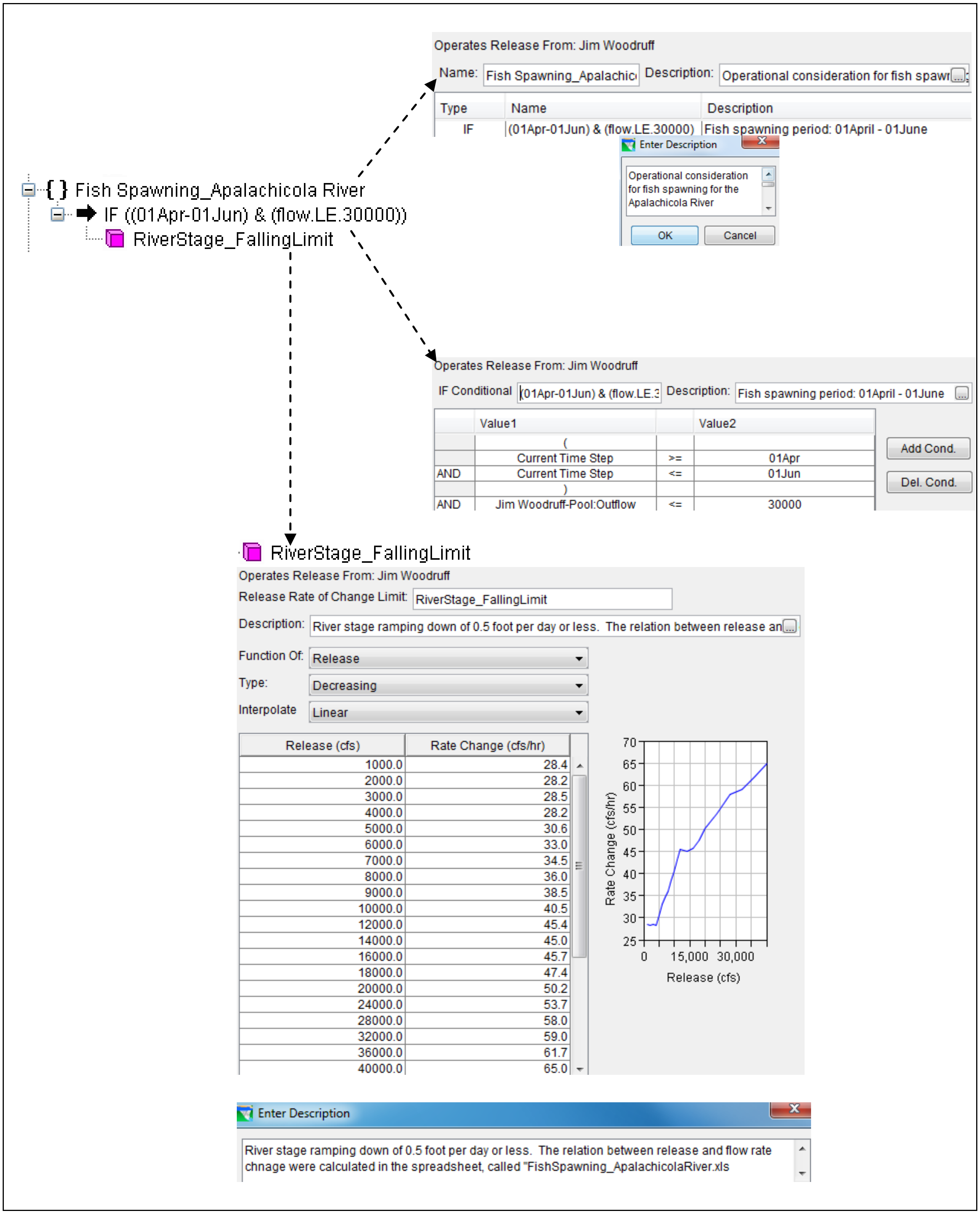


Figure E.15 Fish Spawning on the Apalachicola River -- "Conditional Blocks" and Rule

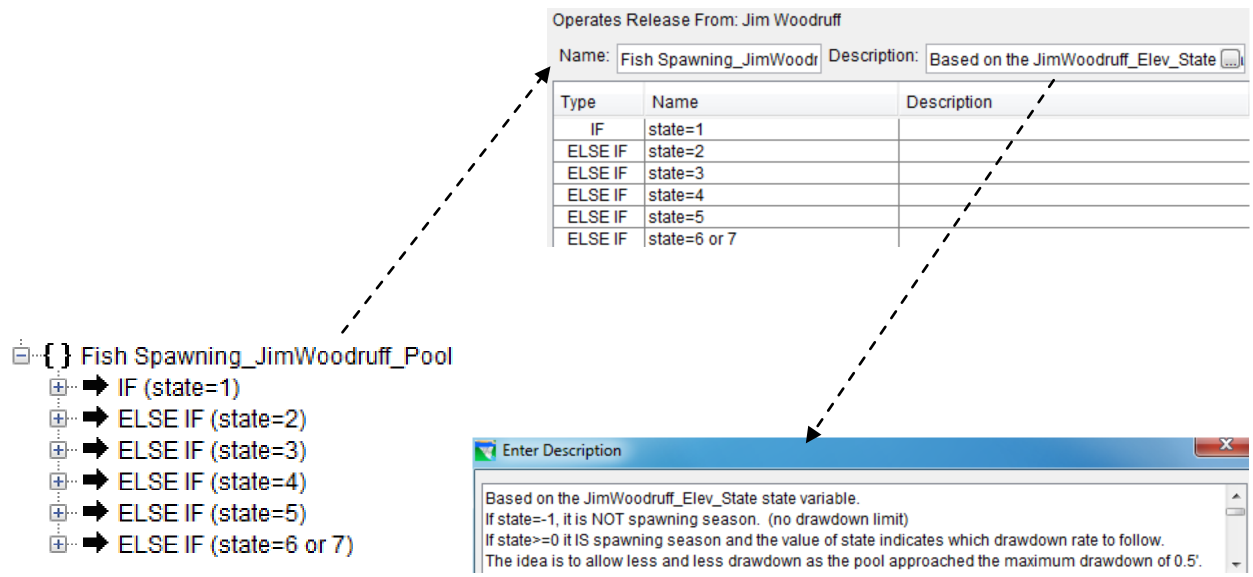


Figure E.16 Fish Spawning at Jim Woodruff -- "Conditional Blocks"

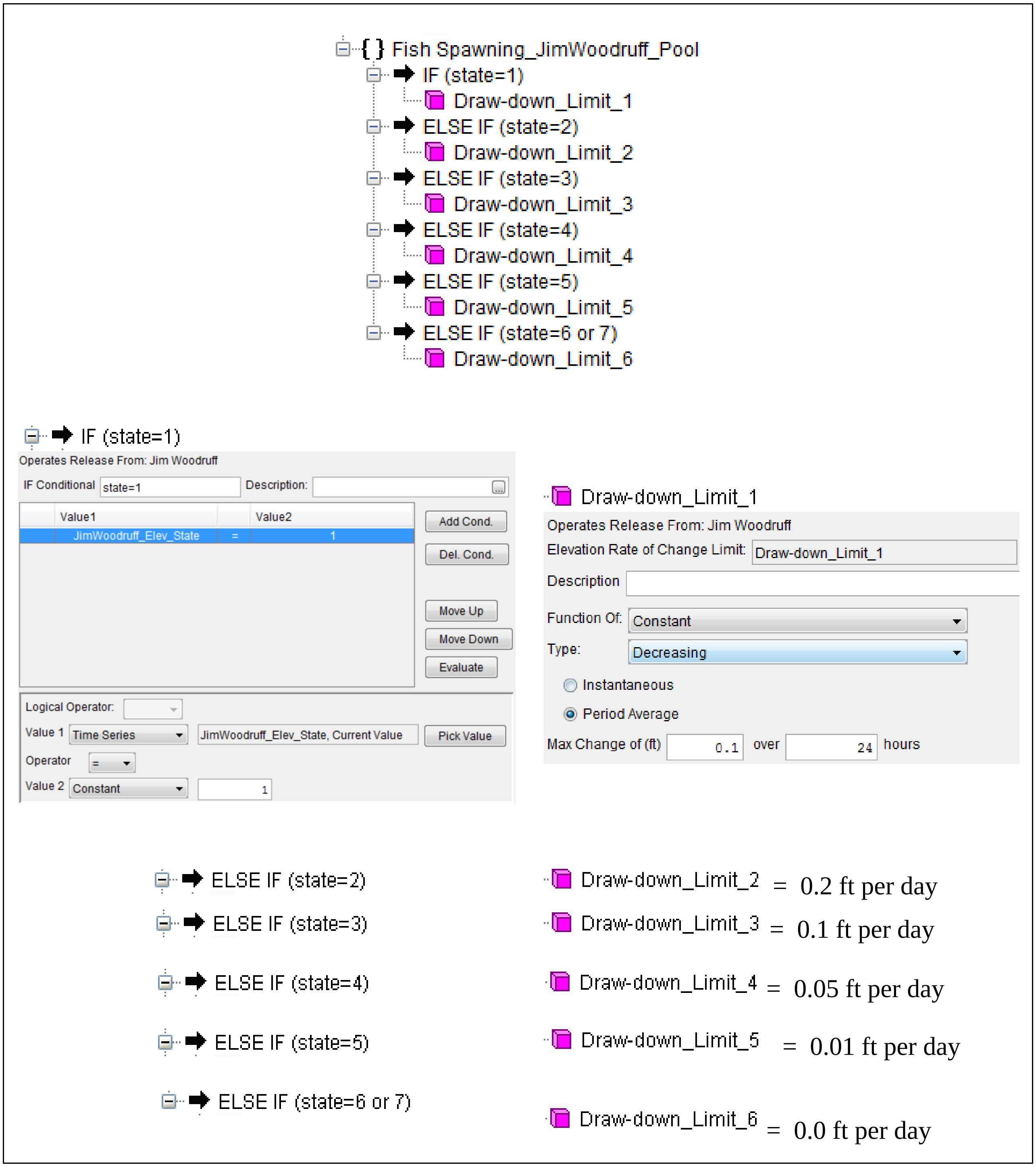


Figure E.17 Fish Spawning at Jim Woodruff -- "IF-Blocks" and "Rules"

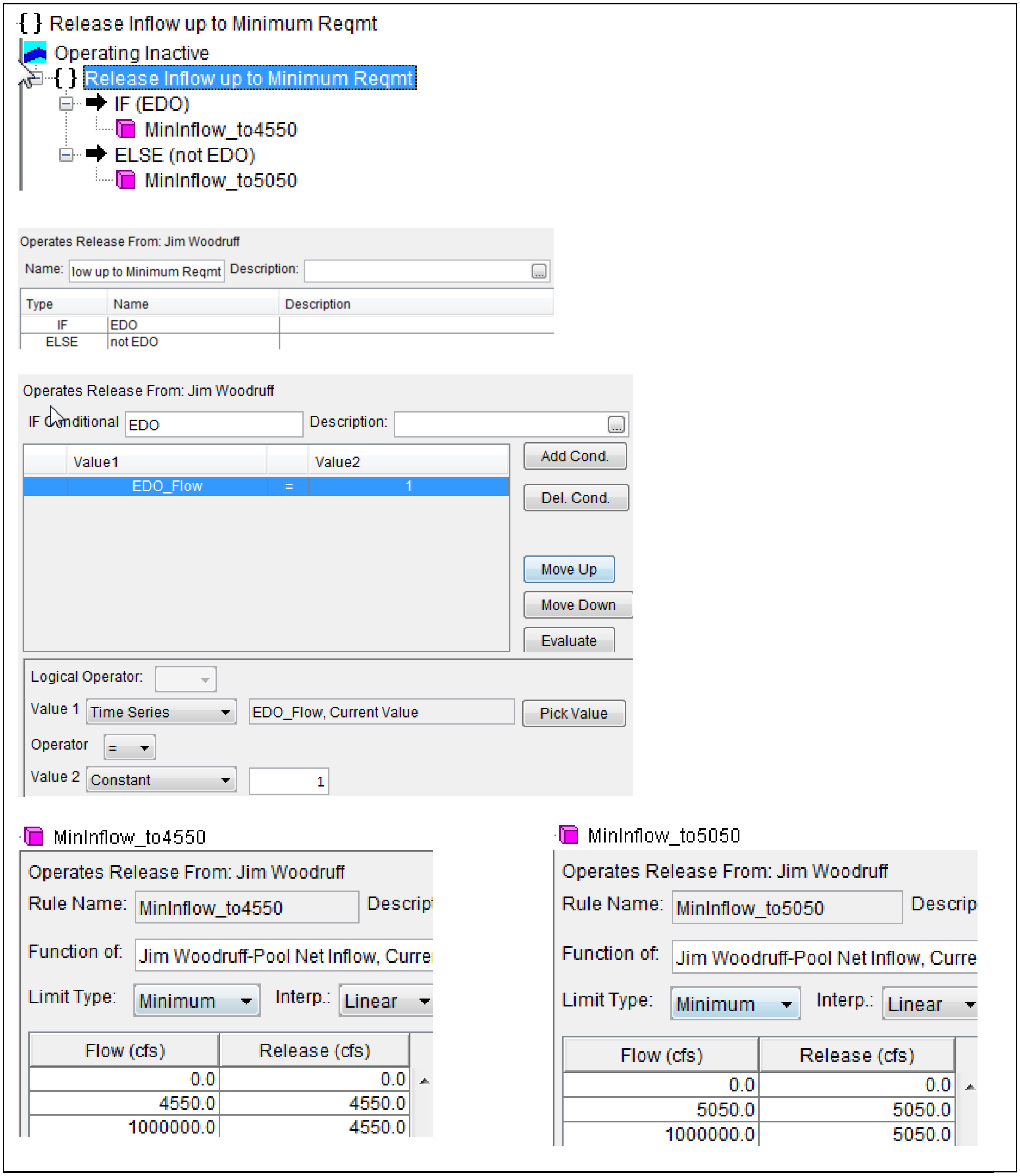


Figure E.18 Release inflow up to Minimum Reqmt-- "IF-Blocks" and "Rules"

C. Rule Descriptions

1. MinRel_HeadLimit

This rule (see Figure E.07) represents the physical operation constraint of the maximum head limit at Jim Woodruff Dam. A head limit curve, which was provided by the Mobile District, defines the minimum tailwater elevation necessary to adequately limit the head difference for a given reservoir pool elevation. A state variable, "Woodruff_MinTailwater", is created to determine the minimum tailwater elevation based on the head limit curve. Using the pool elevation at the previous time step, the state variable script computes the minimum tailwater elevation for the current time step. In the ResSim model, the minimum tailwater elevation is converted to a discharge value based on the tailwater stage-discharge rating curve at the downstream USGS Chattahoochee gage and is used as a minimum release from Jim Woodruff. This head limit rule is placed at the top of each zone indicating the highest rule priority for each zone.

2. { } Flow Target

This conditional logic (see Figure E.08) describes the complex operational requirements to represent a modification of the current Interim Operations Plan at Jim Woodruff Dam. The Revised Interim Operations Plan (RIOP) establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table E.02. Details of the proposed action are described in a separate document, entitled "May 2012 Finding of No Significant Impact and Environmental Assessment, Revised Interim Operations Plan for Threatened and Endangered Species". (http://www.sam.usace.army.mil/Portals/46/docs/planning_environmental/acf/docs/May2012RIOP-EA.pdf) ,hereafter referred to as RIOP2012.

Table E.02 Proposed Action Modified IOP Releases from Jim Woodruff Dam (Source: RIOP2012)

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage[1]
March – May (Spawning season)	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June – November (Non-spawning season)	Zones 1, 2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December – February (Winter)	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4 Or Drought Ops	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	>= 4,500[2]	Up to 100% BI > 4,500

[1] Consistent with safety requirements, flood control purposes, and equipment capabilities.
[2] Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/day drop.

To implement the proposed actions in RIOP2012, a number of state variables are created to determine basin inflow (BI), composite storage (CS), basin inflow fall rate, and seasons. Based on the active composite storage and composite action zones, the state of the composite storage is defined as follows:

Composite Storage State	Definition
0	Above conservation zone (flood pool)
1	Between top of conservation zone and top of zone 2 (within Zone 1)
2	Within Zone 2
3	Within Zone 3
4	Within Zone 4
5	Within drought zone

In addition, a state variable, called "DO4-1," is created to track the drought conditions. The drought plan is "triggered" when composite storage falls below the bottom of Zone 3 into Zone 4.The drought plan provisions remain in place until conditions improve such that the composite storage reaches a level above the top of Zone 2 (i.e., within Zone 1). The drought plan is in effect if it holds a value of 1 (i.e., "true"). There is another state variable, named "*EDO_Flow*", to track if Jim Woodruff needs to release an exceptional drought operation (EDO) minimum flow. For details of all these state variables, refer to Appendix H.

Figure E.09 shows that there are three IF-Blocks under the conditional *Flow Target* logic. It defines if the current condition is in Drought Operations, if the composite storage is in Zone 4 or Zone 5, or if the composite storage is above Zone 4.

3. MinRel_4550 and MinRel_5050

These two rules (see Figure E.10) reflect that when the state variable, "EDO_Flow", holds a value of 1, Jim Woodruff releases a minimum of 4,550 cfs under an exceptional drought operation. Otherwise, the minimum release is 5,050 cfs. Also, when the pool is in composite storage Zone 4 or above the MinRel-5050 is active. It should be noted that these required minimum flow values from RIOP2012 are increased by 50 cfs in the model to ensure a "factor of safety" and more representative of actual operations to meet the minimum flow requirement.

4. { } Seasons

RIOP2012 (Table E.02) specifies the minimum release from Jim Woodruff as a function of seasons, composite storage, and basin inflow. It divides a year into three seasons: (a) spawning season -- March through May; (b) non spawning season -- June through November; and, (c) winter -- December through February (see Figure E.12).

a. IF (Spawning (Mar – May))

During the fish spawning season, the minimum flow releases are different when the active composite storage is within Zones 1 and 2 or within Zone 3.

Under each condition, the minimum release is dependent on the basin inflows. For example, within Zones 1 and 2, the following release schedule is defined:

Basin Inflow (cfs)	**Minimum Release (cfs)**
>= 34,000	25,000
>=16,000 and < 34,000	16,000 +50% of BI
>=5,000 and < 16,000	BI
< 5,000	5,050

To specify these minimum flow releases, several minimum flow rules are used, including: *MinRel_25000*, *MinRel_0.5xBI7D_16000*, *MinRel_0.5xBI7D_11000*, *MinRel_BI*, and *MinRel_5050* (see Figure E.11).

b. ELSE IF (Non Spawning (Jun – Nov))

During the non-spawning season (June through November), the minimum flow releases are dependent on the basin inflow only. The release schedule is defined as follows:

Basin Inflow (cfs)	**Minimum Release (cfs)**
>= 22,000	16,000
>=10,000 and < 22,000	10,000 +50% of BI
>=5,000 and < 10,000	BI
<5,000	5,050

To specify these minimum flow releases, four minimum flow rules are used, including *MinRel_16000*, *MinRel_0.5xBI7D_10000*, *MinRel_BI*, and *MinRel_5050* (see Figure E.12).

c. ELSE (Winter (Dec – Feb))

In winter months (December through February), the minimum flow release is 5,050 cfs, regardless of the composite storage and basin inflow (see Figure E.12).

5. { } Ramp_ Rate_DO4-1

This conditional logic (see Figure E.13) describes maximum fall rates (or down-ramping rates), measured at the Chattahoochee gage, and describes drought contingency operations.

6. { } Hold_RR

This conditional logic (see Figure E.13) is used to maintain the RIOP-Falling Ramp Rate rule when Drought operation first occurs until the target minimum flow is reached, at which point the RIOP-Falling Ramp Rate is suspended. The target minimum flow is 5050 cfs during Drought Operation (DO) and 4550 cfs during Exceptional Drought Operation (EDO).

7. BI-Falling Ramp Rate

This rule (see Figure E.13) sets the fall rates under the drought operation. According to RIOP2012, when the drought operation is in effect, the fall rate matches the fall rate of the basin inflow, which is calculated in the state variable, "BIFallRate". Also, when BI is rising for flow less than 22,000 cfs the falling ramp rate is limited to 2 ft fall rate.

8. RIOP-Falling Ramp Rate PA2:

RIOP2012 specifies the maximum fall rates in river stages when the release is less than or equal to 30,000 cfs. The rate of change in the average daily context is change in river stage from one day to the next. Using the discharge-stage rating curve at the downstream Chattahoochee gage, the fall rates in stage are converted to fall rates in discharge. Therefore, a rate of change (decreasing in discharge) rule is established (see Figure E.13).

Table E.03 Proposed Action Modified RIOP Maximum Fall Rate Schedule Composite Storage Zones 1, 2, and 3*

Release Range (cfs)	Maximum Fall Rate (ft/day), measured at Chattahoochee gage
> 30,000**	No ramping restriction***
> 20,000 and <= 30,000*	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and <= 20,000*	0.5 to 1.0
Within Powerhouse Capacity and >= 10,000*	0.25 to 0.5
Within Powerhouse Capacity and < 10,000*	0.25 or less

*Maximum fall rate schedule is suspended in Composite Zone 4
**Consistent with safety requirements, flood control purposes, and equipment capabilities.
***For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control down Ramping rate. Therefore, no ramping rate is required.

The Corps believes that when flows are less than 10,000 cfs, the observed fall rates are more conservative than those reflected in Table E.03 due to the limitations of the equipment and careful operations to avoid violating the maximum fall rate schedule when flows are less than 10,000 cfs. Because the model has limited ability to represent the actual down-ramping operations, USFWS requested that the Corps simulate the RIOP using a fall rate they believed to be more representative of actual operations. The RIOP continues to prescribe fall rates of <0.25 ft/day for releases less than 10,000 cfs, but the Corps simulated the RIOP using a standard 0.13 ft/day fall rate, which is the average fall rate in this range of flows since the Corps implemented the maximum fall rate schedule in September 2006. This is consistent with previous simulations for the 2008 BO (and currently for this BO) that use a slightly higher minimum flow than 5,000 cfs (5,050 cfs) in the model simulation rules to better reflect actual conservative operations in place to avoid violating the 5,000 cfs minimum flow provision. Therefore the ResSim model includes Fall Rate of 0.13 ft/day for Jim Woodruff releases < 10,000 cfs.

9. { } Sturgeon Spawning

This conditional logic (see Figure E.14) represents the Corps' operation strategy for avoiding stranding Gulf sturgeon eggs and larvae when flows are declining from 40,000 cfs during the sturgeon spawning season from March through May. During a 2-week moving time window, when the releases from Jim Woodruff Dam are less than 40,000 cfs, the maximum drop from the Apalachicola River stage on the fourteenth day prior to the current day is 8 feet. A state variable named *MinStage_Chattahoochee* is created to determine the minimum stage on the Apalachicola River for the current day during the sturgeon spawning season. Using the stage-discharge rating curve on the Chattahoochee gage, a minimum flow release rule named *MinRel_forSturgeon* (Figure E.14) is established at Jim Woodruff Dam.

10. { } Fish Spawning_Apalachicola River

The IF-Block and rule (see Figure E.15) 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, and February 2005". In accordance with the procedures of SAM SOP 1130-2-9, during the spawning period, which is April 1 through June 1 on the Apalachicola River, the Corps shall operate generally stable or gradually declining river stages, which are defined as ramping down of half a foot per day or less.

To implement this fish spawning rule, the first step is to determine the maximum decrease in releases from Jim Woodruff as a function of reservoir releases. The fish spawning rule is applied at the Chattahoochee gage on the Apalachicola River. The calculations are shown as follows:

USGS Rating Curve at Station 02358000, "Apalachicola River at Chattahoochee, FL"
The same rating curve was used in the ResSim model at Junction, "Chattahoochee"

Flow (cfs)	Stage (ft)	Release from Woodruff (cfs)	Stage from rating (ft)	Maximum decline in stage in one day	Lowest allowable stage (ft)	Flow from rating curve	Flow decrease in one day	Flow decrease rate (cfs/hr)
3500	38	1000	36.16	0.5	35.66	318	682	28.4
4180	38.5	2000	36.9	0.5	36.40	1324	676	28.2
4900	39	3000	37.63	0.5	37.13	2317	683	28.5
5670	39.5	4000	38.37	0.5	37.87	3323	677	28.2
6480	40	5000	39.06	0.5	38.56	4266	734	30.6
7320	40.5	6000	39.7	0.5	39.20	5208	792	33.0
8200	41	7000	40.31	0.5	39.81	6172	828	34.5
9120	41.5	8000	40.89	0.5	40.39	7135	865	36.0
10100	42	9000	41.43	0.5	40.93	8077	923	38.5
11000	42.5	10000	41.95	0.5	41.45	9028	972	40.5
12100	43	12000	42.95	0.5	42.45	10910	1090	45.4
13100	43.5	14000	43.91	0.5	43.41	12920	1080	45.0
14200	44	16000	44.82	0.5	44.32	14904	1096	45.7
15300	44.5	18000	45.71	0.5	45.21	16862	1138	47.4
16400	45	20000	46.54	0.5	46.04	18796	1204	50.2
17500	45.5	24000	48.12	0.5	47.62	22712	1288	53.7
18700	46	28000	49.61	0.5	49.11	26608	1392	58.0
19900	46.5	32000	51.03	0.5	50.53	30584	1416	59.0
21200	47	36000	52.4	0.5	51.90	34520	1480	61.7
22400	47.5	40000	53.7	0.5	53.20	38440	1560	65.0
23700	48	44000	54.97	0.5	54.47	42404	1596	66.5
25000	48.5	48000	56.19	0.5	55.69	46346	1654	68.9
26300	49	52000	57.25	0.5	56.75	49850	2150	89.6
27700	49.5	57000	58.19	0.5	57.69	54326	2674	111.4
29100	50	62000	59.09	0.5	58.59	59204	2796	116.5
30500	50.5	67000	59.93	0.5	59.43	63994	3006	125.3
31900	51	72000	60.76	0.5	60.26	68960	3040	126.7
33400	51.5	77000	61.55	0.5	61.05	73820	3180	132.5

The next step is to establish a Release Rate of Change Limit rule, *RiverStage_FallingLimit* (Figure E.15), similar to the *Falling Release Ramp Rate* rule in the RIOP operating, and apply it to Jim Woodruff. It should be noted that the fish spawning rule for the Apalachicola River is applicable only when the release from Jim Woodruff is equal to or less than 30,000 cfs (Source: conference call discussions on January 20, 2010).

11.{ } Fish Spawning_Jim Woodruff

This conditional logic (see Figure E.16 through Figure E.17) represents operation requirements for fish spawning in accordance with the procedures of SAM SOP 1130-2-9. During the spawning period, which is March 1 to May 1 for Lake Seminole, 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 H.

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 in as follows:

```
# State variable: JimWoodruff_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
```

The state variable *JimWoodruff_Elev_State* script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is described in Appendix H.

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 E.16 through Figure E.17). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure E.16 through Figure E.17):

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

12. Release inflow up to Minimum Reqmt

This conditional logic (see Figure E.18) represents the release relationship between inflow to Jim Woodruff and dam releases in the Operating Inactive zone. There are two minimum release rules to reduce impacts from zone boundary restriction in the Operating Inactive zone. Depending on the value of the Exceptional Drought Operations (EDO), the minimum flow requirements ranges between 4550 cfs and 5050 cfs.

a. **MinInflow_to4550**

If in Exceptional Drought Operations (EDO = 1), then release inflow into Lake Seminole (up to 4550 cfs).

b. **MinInflow_to5050**

If in Normal or Drought operations (EDO = 0), then release inflow into Lake Seminole (up to 5050 cfs).

IV. Alternative Operations

Different operation sets were created to implement revisions to certain concepts in the "NO-Action" operation set at Jim Woodruff. The concepts subject to revision are listed below:

- Basin Inflow
- Flow Target
- Navigation
- Ramping Rate
- Ramping Rate suspension during Drought Operation
- Ramping Rate suspension during Prolonged Low Flow operation
- Drought Operation trigger zone
- Drought Operation suspension zone

Jim Woodruff Reservoir was modeled using a different operation set for each of the eight study alternatives. The operation sets used with each alternative are given in Table E.04. Table E.05 describes each operation set.

Table E.04 Alternatives, Operation Sets, and Reservoir Network Used at Jim Woodruff

Alternative	Operation Set	Reservoir Network
NOAction	NO-Action	2014_Base
Alt1	NO-Action	2014
Alt2	Silver	2014
Alt3	Crimson	2014
Alt4	Orange	2014
Alt5	Peach	2014
Alt6	Blue	2014
Alt7	Gold	2014

Table E.05 Operation Sets Used at Jim Woodruff

Operation Set	Description
NO-Action	Current operation / no action.
Silver	Same as NO-Action operation set except Silver uses **4/5 month Navigation** and **Suspends Ramping Rate during Prolonged Low Flow**.
Crimson	Same as Silver operation set except Crimson uses **Tri-Rivers Navigation**.
Orange	Same as NO-Action operation set except Orange uses **4/5 month Navigation**, **FL Basin Inflow**, **FL Flow Target**, **FL Ramping Rate** which is not suspended under any conditions. Drought operation is not defined for this alternative.
Peach	Same as NO-Action operation set except Peach uses **4/5 month Navigation**, **GA Basin Inflow**, **GA Flow Target**, and **Suspends Ramping Rate after Pulse Flow**.
Blue	Same as NO-Action operation set except Blue uses **4/5 month Navigation, FWS Flow Target** and **Suspends Drought Operation at Zone 3** which affects the navigation rule.
Gold	Same as NO-Action operation set except Gold uses **4/5 month Navigation** and **Triggers Drought Operation at Zone 3** which affects the navigation rule.

A. *Silver* Operation Set

The Silver operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to navigation and suspending ramp rate during prolonged low flow operation. Figure E.19 shows a set of operational rules specified for each zone that reflects the operation set named “Silver”.

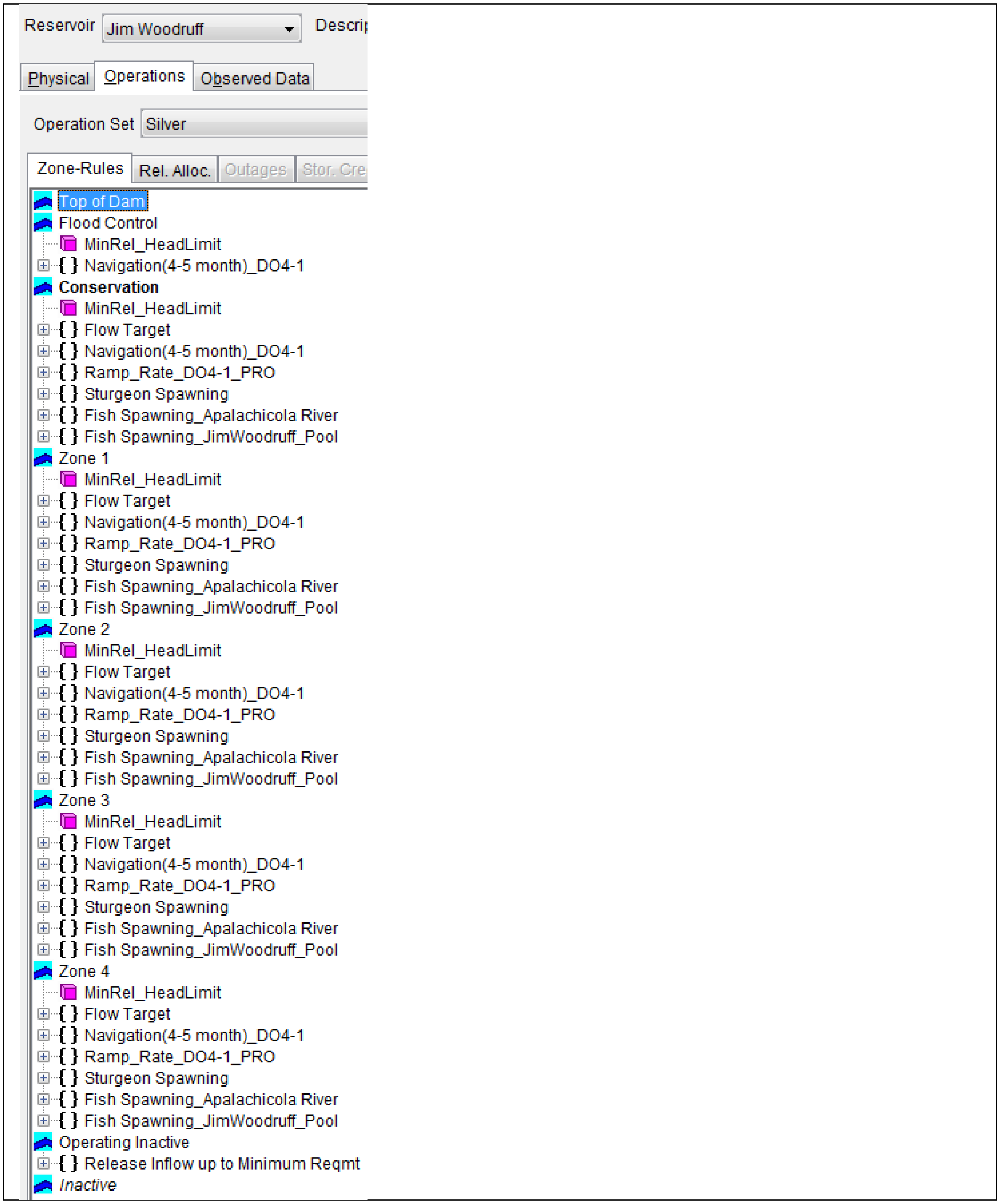


Figure E.19 Reservoir Editor- Network 2014: Operations Tab – Silver OpSet – Zones and Rules

1. Navigation (4-5 month) _DO4-1

Navigation operation rules were added to the NO-Action operation set to model the feasibility of a five month navigation season from January through May. The goal is to maintain a flow rate of 16,200 cfs at Blountstown as much as possible, which represents 7 ft of minimum navigation depth. The added rules apply consistently within the five conservation zones, at a lower priority than the “Flow Target” logic but higher priority than the “Sturgeon Spawning” rules.

Nested conditional statements use existing RIOP state variables as well as one named *NavigationSeason*, which indicates whether the release decision occurs during January-May. If true, and if the system composite storage zone is 1 or 2 and not under drought operations then the minimum release rule *MinRel_Navigation* specifies release. The settings are shown in Figure E.20 and Figure E.21. Description of the state variables can be found in Appendix H.

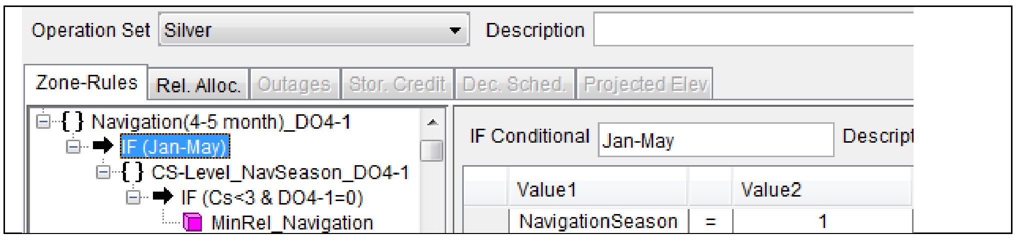


Figure E.20 Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

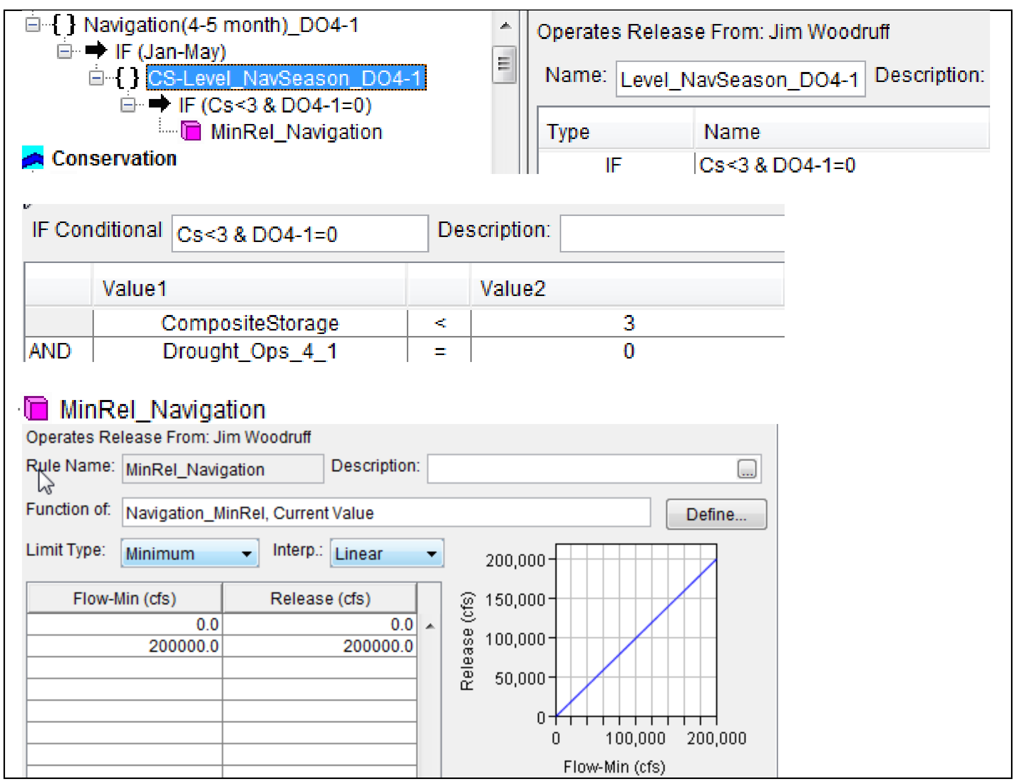


Figure E.21 Release Rules for *Navigation(4-5month)_DO4-1* Rule

2. Suspend Ramping Rate during Prolonged Low Flow

The Silver operation set suspends Ramping Rate required by the RIOP during prolonged low flow situation. The state variable *ProlongedLowFlow* shown in Figure E.22 described in Appendix H. The Proloned Low Flow criteria, suspend maximum fall rates when flows have been < 7,000 cfs for 30 days, and resume when flows > 10,000 cfs for 30 days. If flow conditions are met and the state variable equals 1, then *BI-Falling Ramp Rate* rule is used instead of *RIOP-Falling Ramp Rate PA2.*

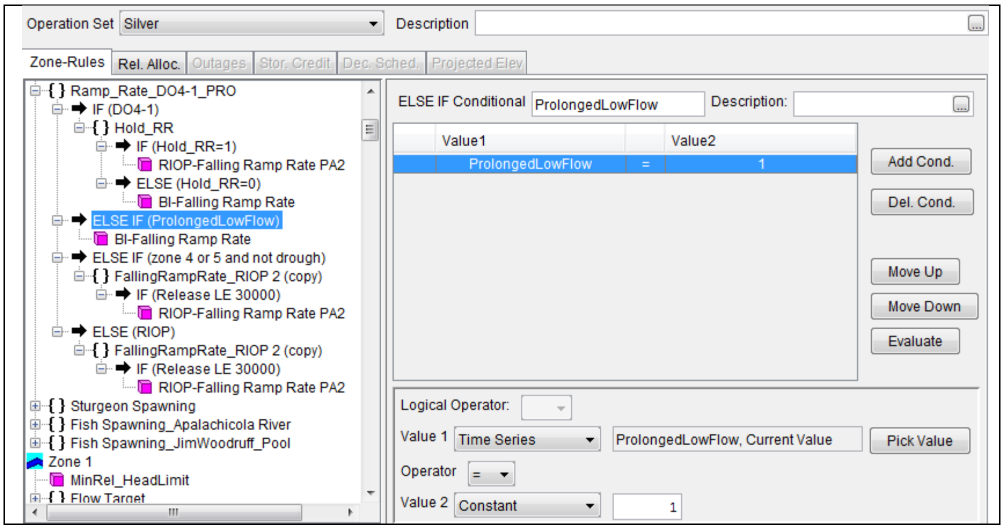


Figure E.22 Conditional Block for *Ramp_Rate_DO4-1_PRO* Rule

B. *Crimson* Operation Set

Figure E.23 shows a set of operational rules specified for each zone that reflects the operation set named “Crimson”.

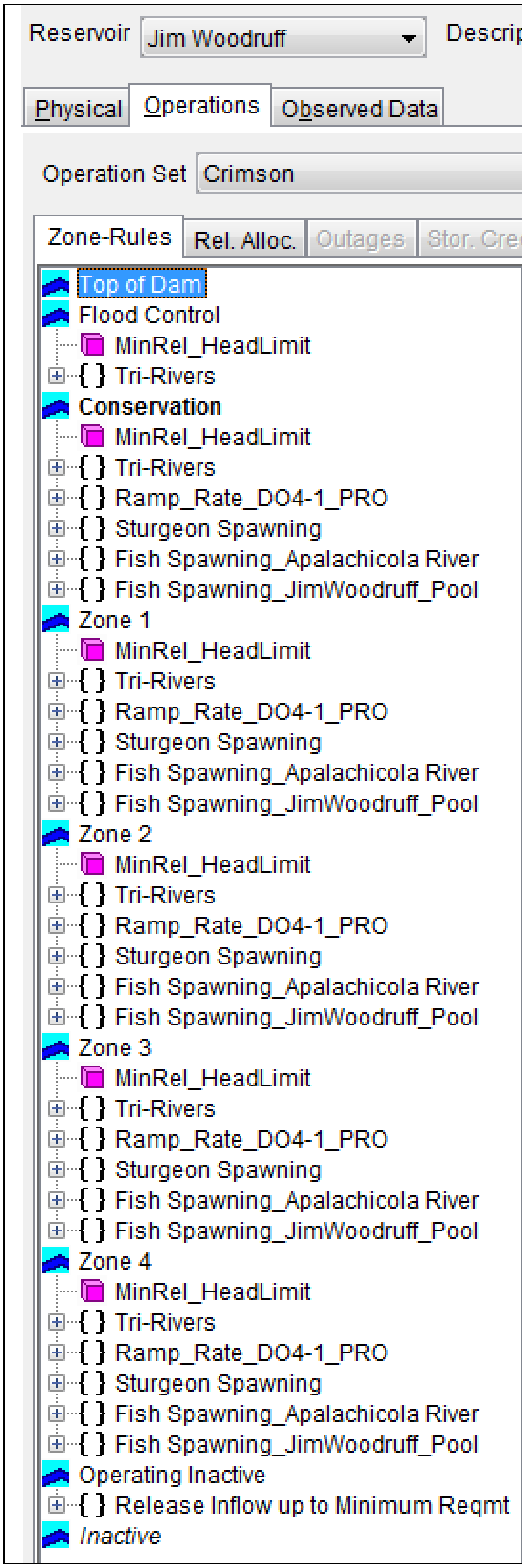


Figure E.23 Reservoir Editor- Network 2014: Operations Tab – Crimson OpSet – Zones and Rules

The Crimson operation set modifies the “Flow Target” logic from the NO-Action operation set to reflect the Tri-Rivers Navigation rule. This establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table E.06. The operation set preserves the releases attributes of the RIOP2012 and integrate navigation support into the transition periods between average to high flows where no navigation support was necessary and moderate/low flows when augmentation from the reservoir was necessary. Two important concepts also integrate into this approach, there is a limit to the amount of augmentation which can be supported by the ACF federal reservoirs and flow target are based on no dredging occurring in the Apalachicola River. Table E.07 listed the flow requirements to provide 3 navigation depths. The 'JimWoodruff Q' column represents the Jim Woodruff estimated release required to provided the corresponding navigation depth. For example, a Jim Woodruff release of 18,800 cfs will provide the 9 ft channel depth in the Apalachicola River. This is based on a correlation of Blountstown and Chattahoochee flow data for the period 1999-2008. An augmentation amount of 3,000 cfs selected to test the concept. So if the navigation channel was to be provided a 18,800 cfs flow and the augmentation limit was 3,000 cfs then if local inflow was greater than 15,800 (18,800 - 3,000) then the model will release 18,800 to support the 9-foot channel.

Table E.06 Tri-Rivers Navigation Rule from Jim Woodruff Dam

Months	Composite Storage Zone	Basin Inflow(BI)(cfs)	Release from JWLD(cfs)
Mar-May	Zone 1	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 2	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ+50%BI>9 ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 3	>=39,000	=25,000
		>=9ft NavQ-9ft Augmentation	= 9 ft NavQ+50%BI>9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
Jun-Nov	Zones 1,2, and 3	>=22,000	=max(16,000;9ft NavQ)
		>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ

		>=10,000 and <7ft NavQ- 7ft Augmentation	=10,000 + 50% BI>10,000
		>=5,000 and <10,000	=BI
		<5,000	=5,000
Dec-Feb	Zones 1,2, and 3	>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		<7ft NavQ- 7ft Augmentation	=5,000
At all times	Zone 4	NA	=5,000(Store all BI>5,000)
At all times	Corps Exceptional Drought Trigger Zone	NA	=4,500(Store all BI>4,500)*
*Once composite storage falls below the top of the Corps Exceptional Drought Trigger Zone ramp down			
9ft NavQ = 18,800 cfs 8ft NavQ = 17,400 cfs 7ft NavQ = 16,100 cfs			

Table E.07 Flow requirements to provide 3 navigation depths

Navigation Depth	Blountstown Q	JimWoodruff Q	Augmentation
9	20,600	18,800	3,000
8	18,300	17,400	3,000
7	16,200	16,100	3,000

The content of Tri-Rivers Navigation rule in the ResSim model is shown in Figure E.24 through Figure E.29.

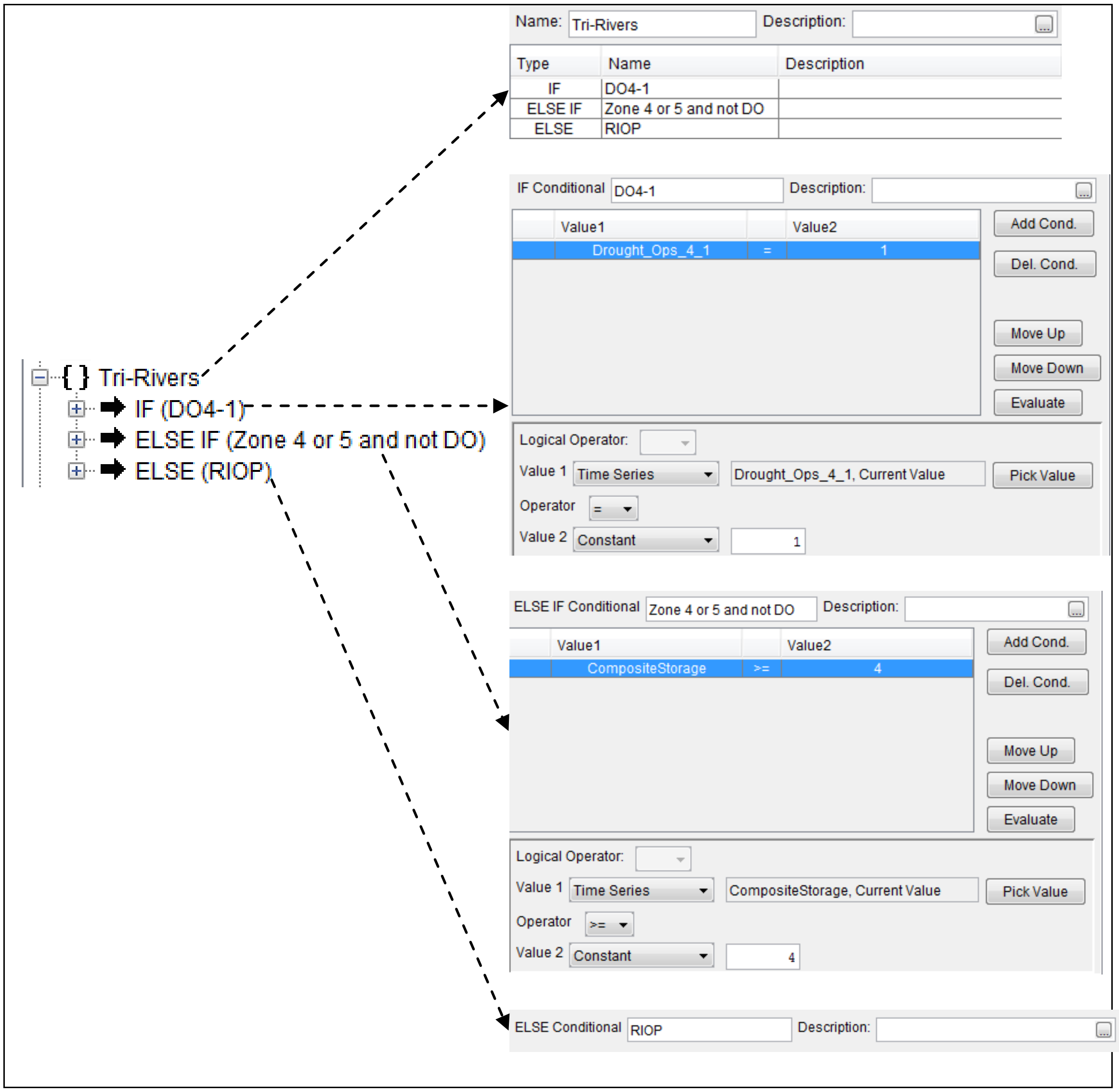


Figure E.24 Tri-Rivers *(Part 1 of 6)*: Overview of " IF (DO4-1) - Else IF (Zone 4 or 5 and not DO) -Else (RIOP)"

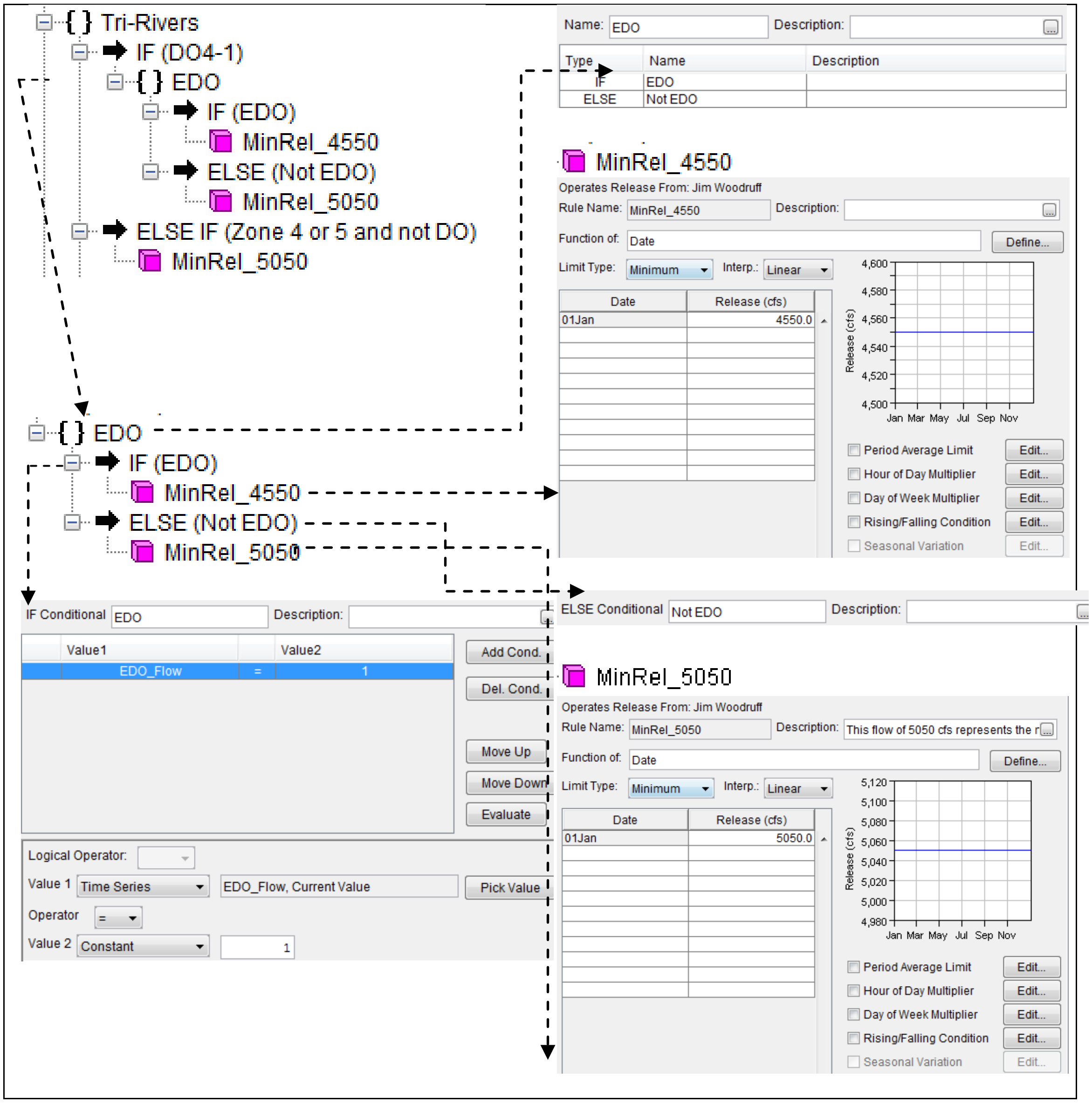


Figure E.25 Tri-Rivers *(Part 2 of 6)*: Drought Operations ,Checking for "EDO" , "MinRel_4550"and Not EDO, "MinRel_5050"

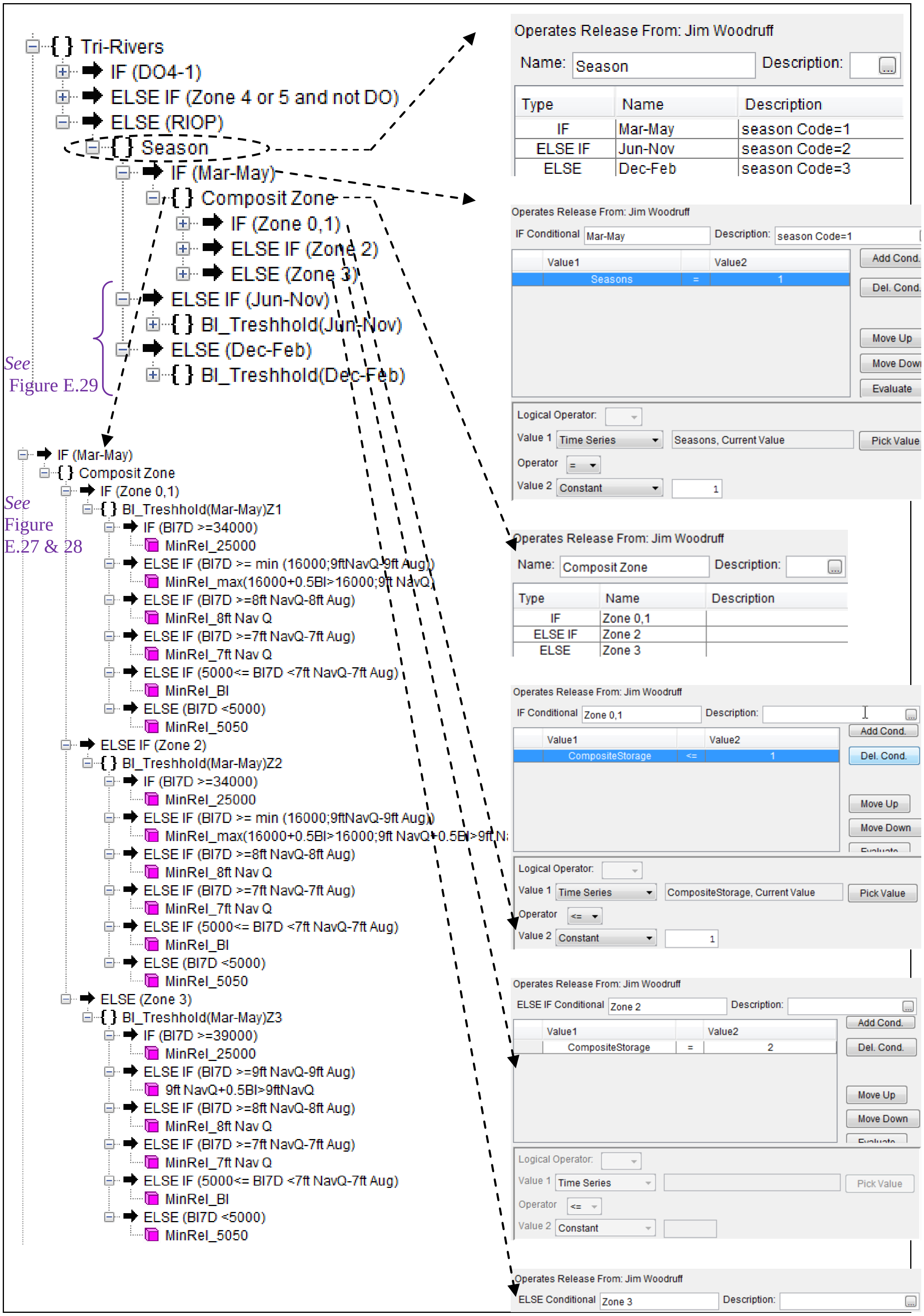


Figure E.26 Tri-Rivers *(Part 3 of 6)*: Season– "Overview" and check for "(Mar-May)" – *Part 1 of 3*

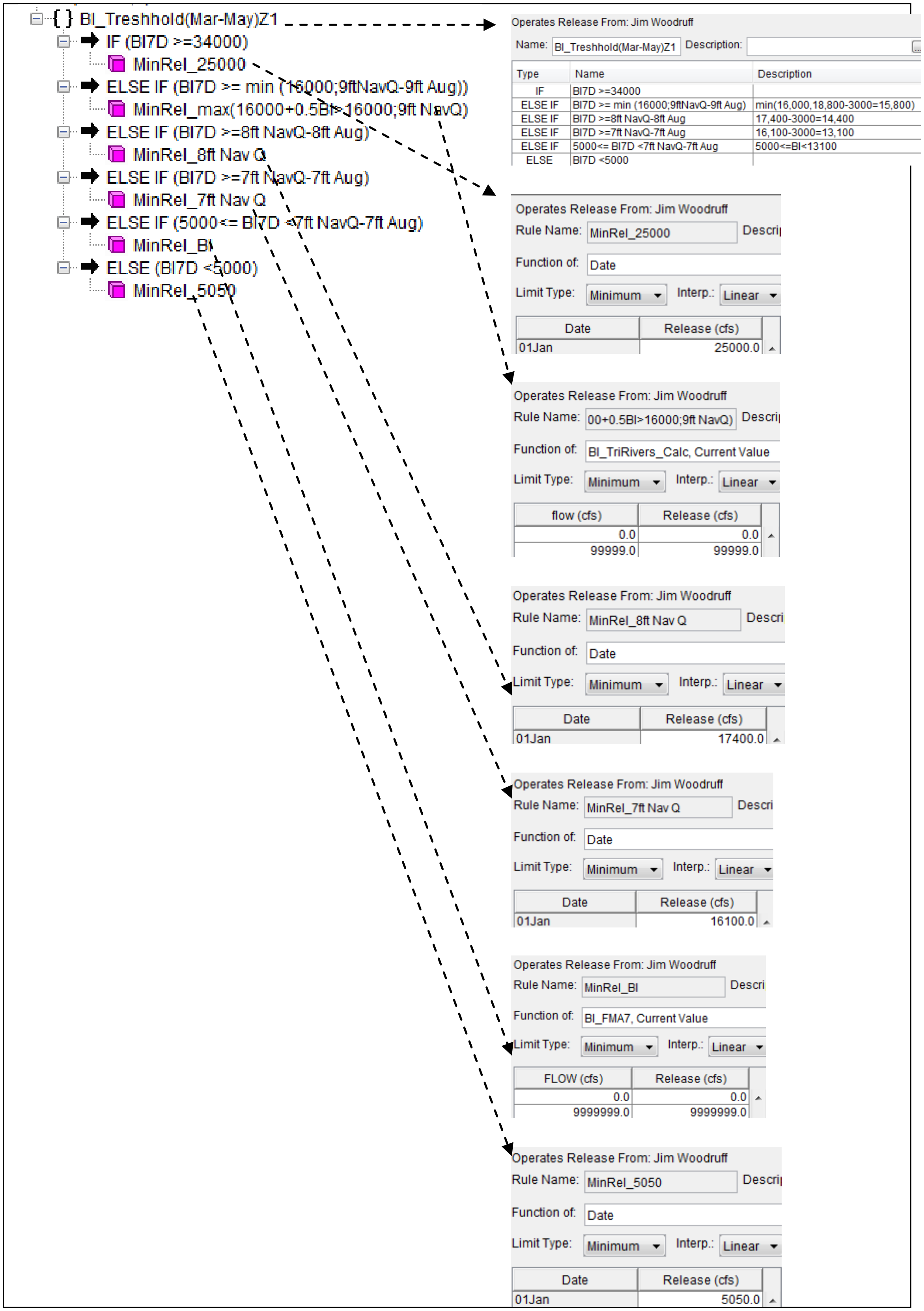


Figure E.27 Tri-Rivers *(Part 4 of 6)*: Season– "Overview" and check for "(Mar-May)" – *Part 2 of 3*

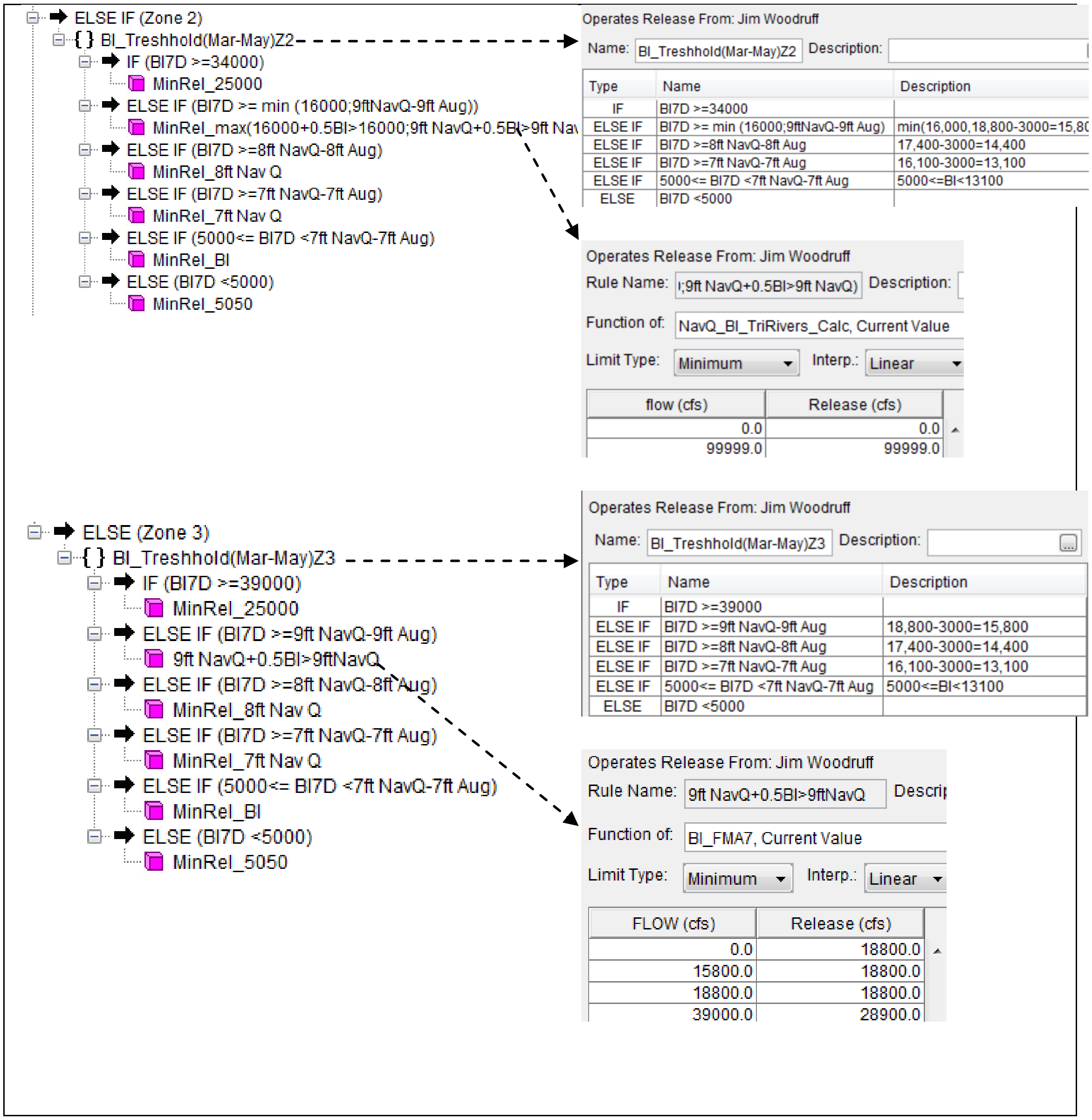


Figure E.28 Tri-Rivers (Part 5 of 6): Season– "Overview" and check for "(Mar-May)" – Part 3 of 3

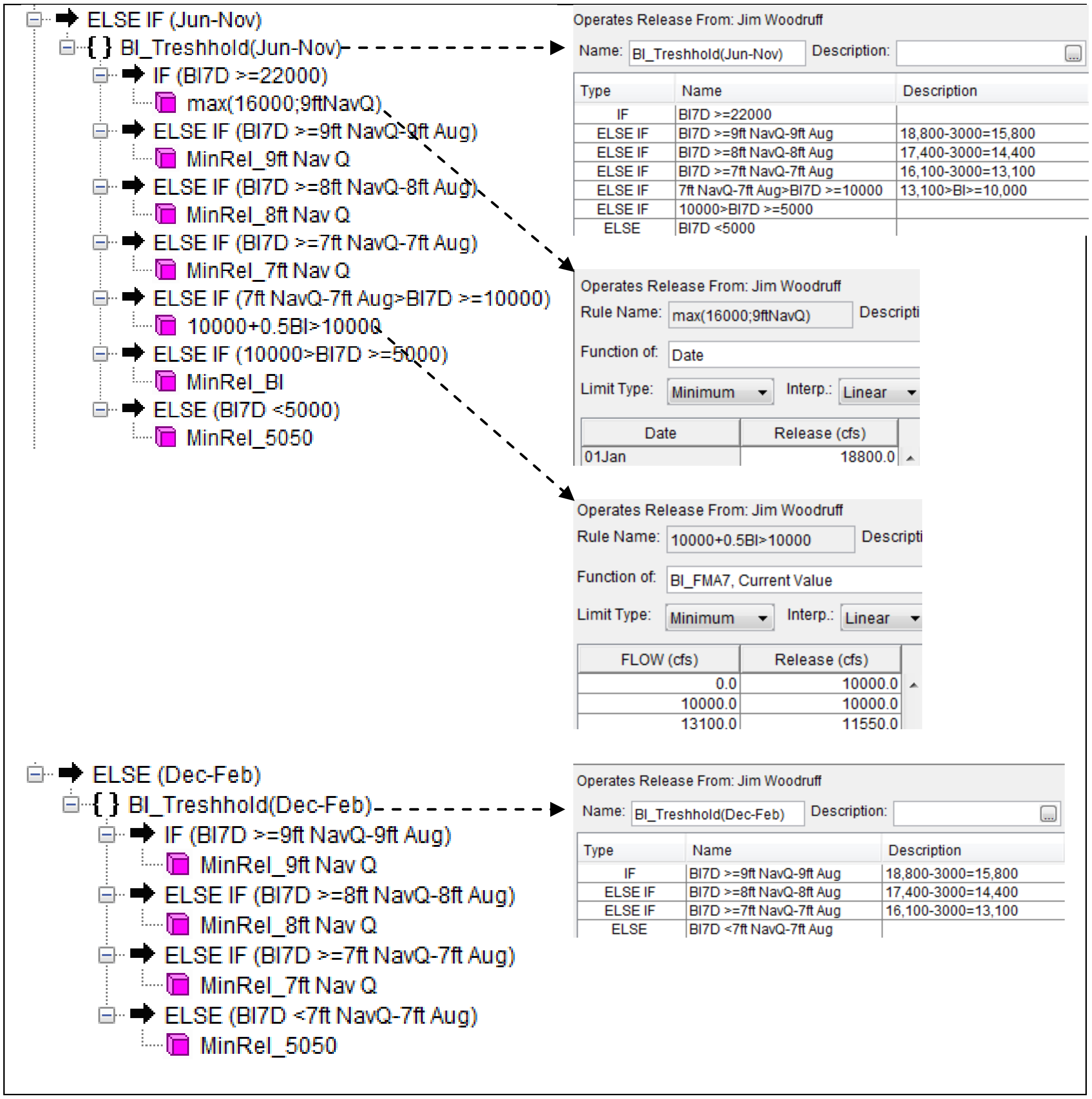


Figure E.29 Tri-Rivers (Part 6 of 6): Season– "Overview" and check for "(Jun-Nov)" and "(Dec-Feb)"

Unlike the "Flow Target" logic of the No_Action operation set, the Tri-Rivers Navigation rule applies to the flood control zone (at lesser priority than the head limits rule).

The Crimson operation set also employs the "Suspend Ramping Rate during Prolonged Low Flow" rules in the same way as the Silver operation set.

C. *Orange* Operation Set

The Orange operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to Navigation, Florida Basin Inflow, Florida Flow Target, and Florida Ramping Rate. It also applies the MinRel_5050 rules at highest priority to the flood control zone and all conservation zones. Figure E.30 shows a set of operational rules specified for each zone that reflects the operation set named "Orange".

MT_compute Drought state, MT_compute Basin Inflow, and MT_compute FL Basin Inflow are zero minimum flow rules as shown in Figure E.31, Figure E.32, and Figure E.33 respectively. These rules are used to apply a modeling technique in HEC-ResSim to trigger the variables that need to be known either by the user or by the other variables in the model.

"Drought_Ops_4_1" is not used by any of the rules in the Orange operation set, but the user needs to know its values for post processing review. "MT_compute Drought state" rule triggers "Drought_Ops_4_1" state variable and provides the values of this variable without affecting the system. Also, "FL_Flow Target" state variable needs to know the values of "BI_FMA7" and "FLBI_FMA7" to compute the "FL Flow Target" rule. MT_compute Basin Inflow, and MT_compute FL Basin Inflow rules trigger the BI_FMA7" and "FLBI_FMA7" state variables without affecting the system.

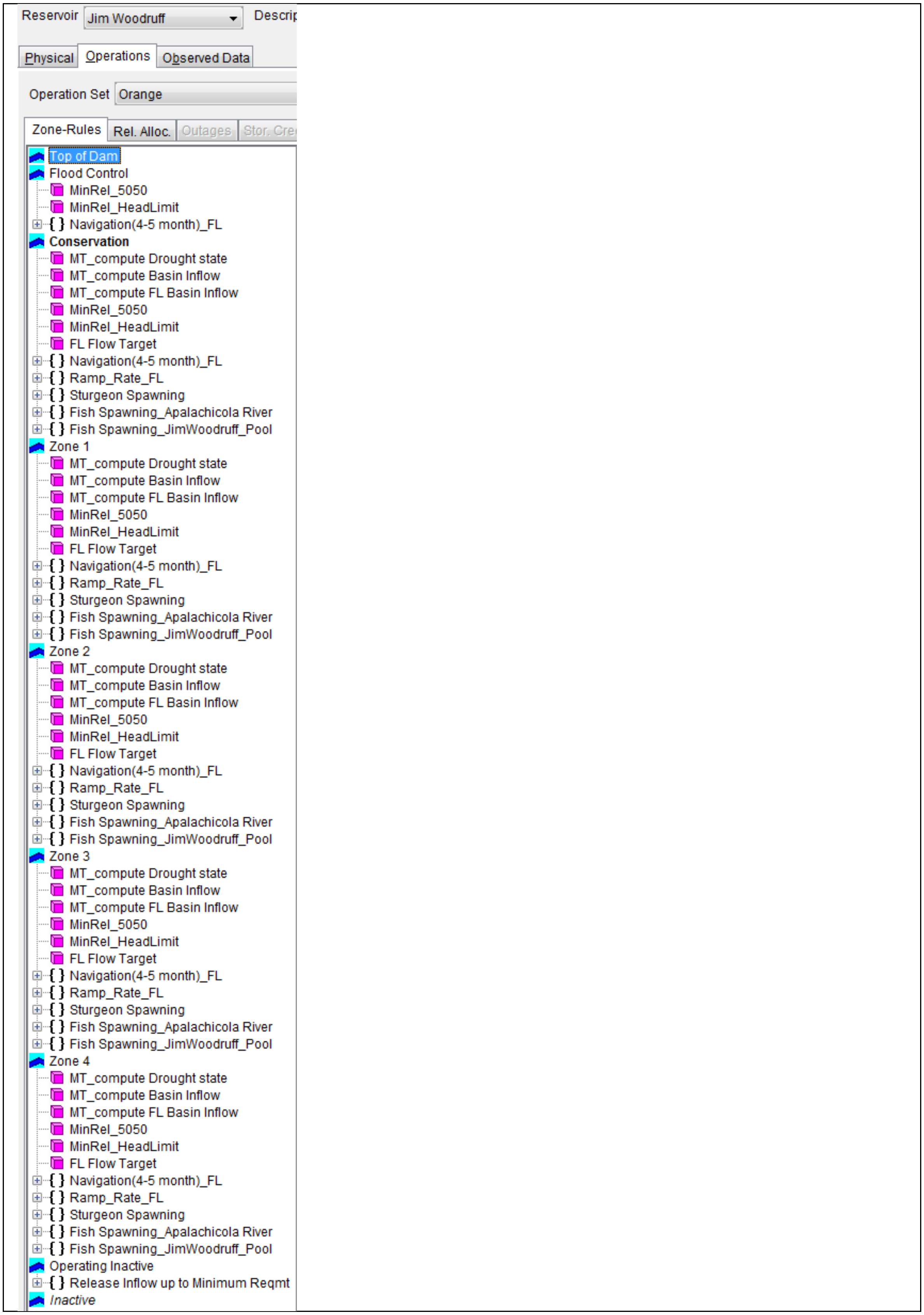


Figure E.30 Reservoir Editor- Network 2014: Operations Tab – Orange OpSet – Zones and Rules

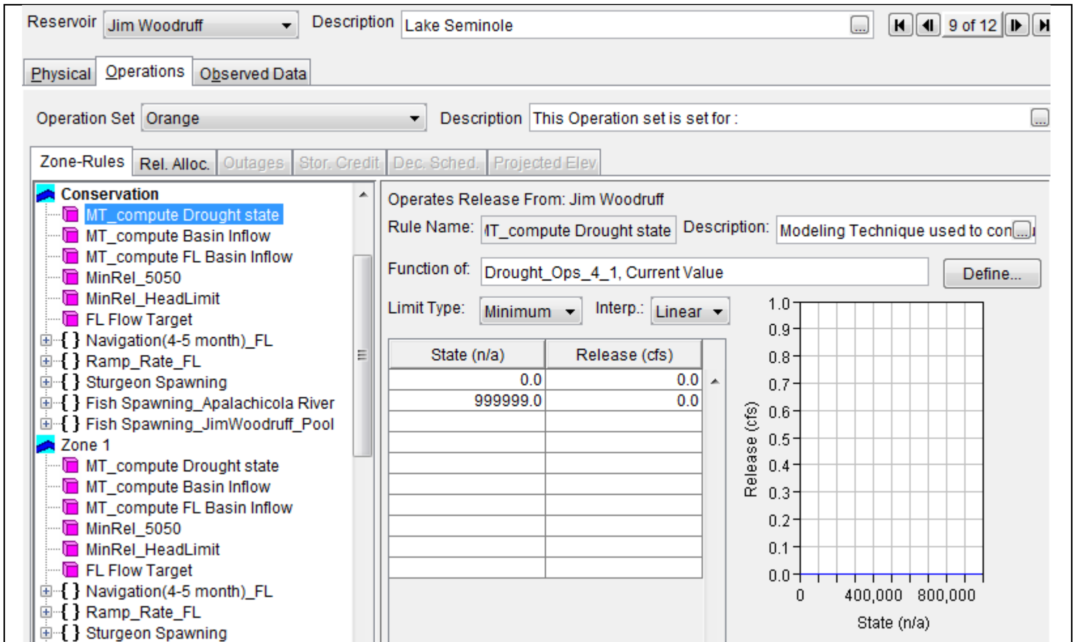


Figure E.31 MT_compute Drought state rule

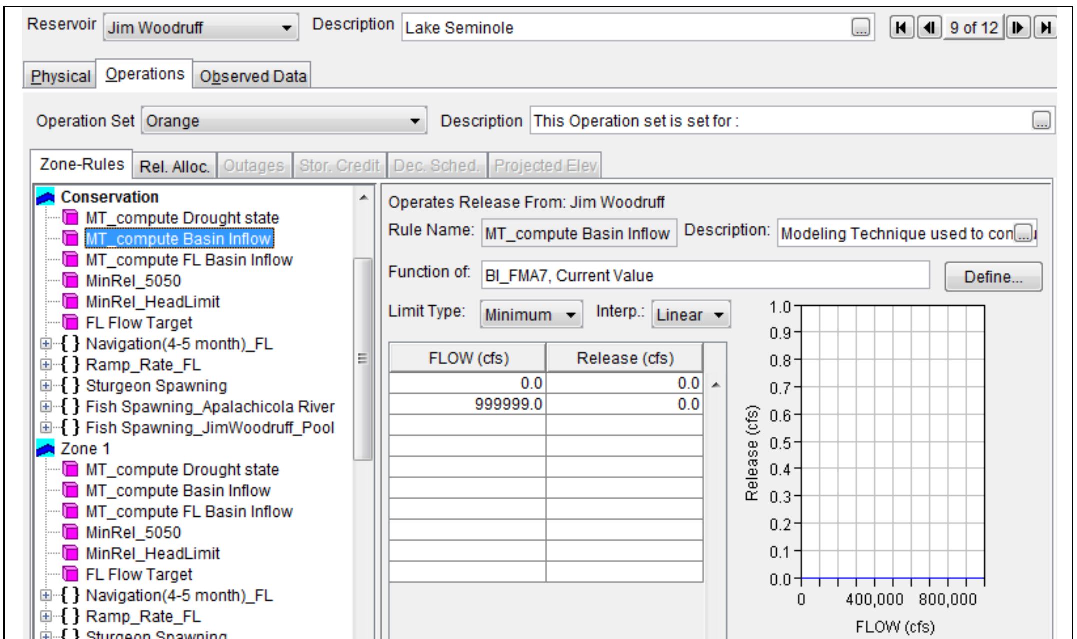


Figure E.32 MT_compute Basin Inflow rule

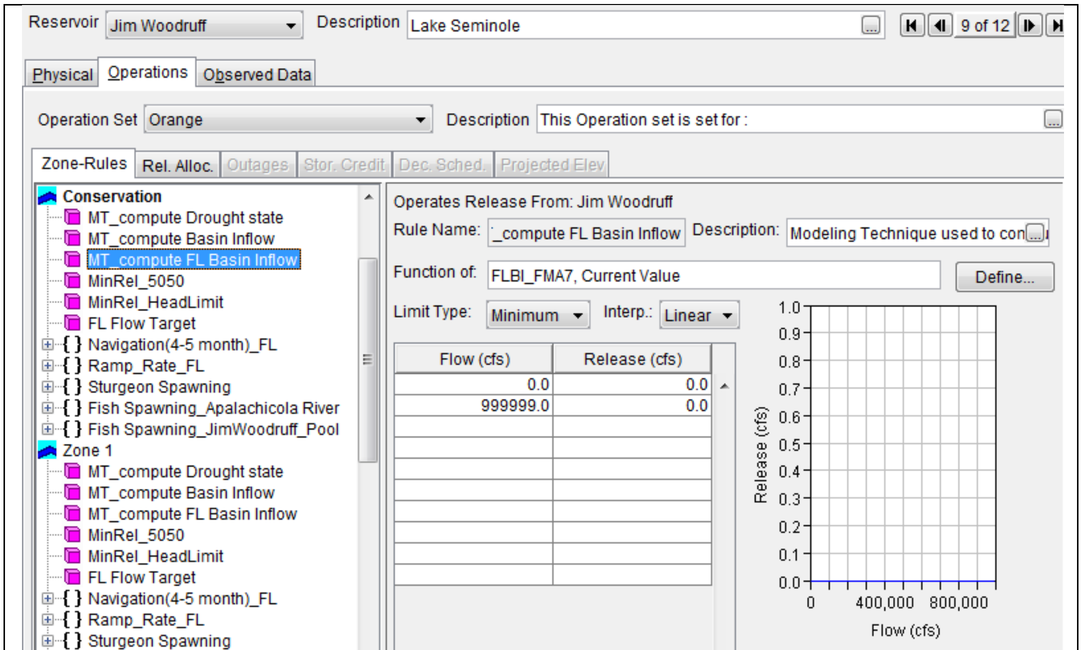
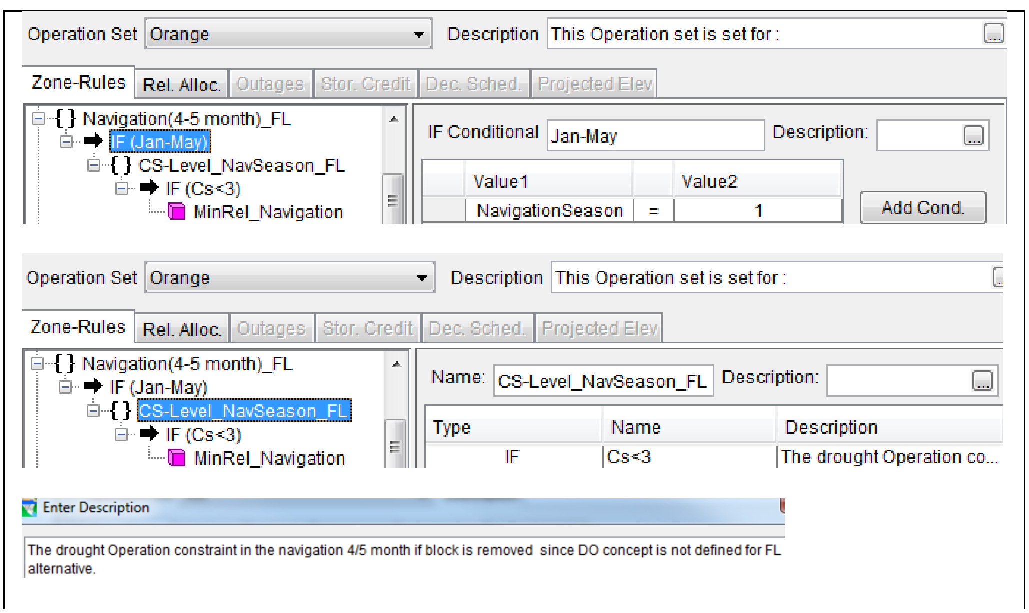


Figure E.33 MT_compute FL Basin Inflow rule

1. *Navigation (4-5 month) _FL*

The *Navigation (4-5 month) _FL* rule closely resembles the rule used in the Silver operation set, except that this version does not consider the drought state. Settings for *Navigation (4-5 month) _FL* rule are shown in Figure E.34. The state variable *NavigationSeason* defines the navigation season between January and May and *MinRel_Navigation* rule initiates the release of all incoming flow to help achieve flows 16,200 cfs at Blountstown, which provides 7 ft of navigation depth. The rule applies to the flood control zone and all conservation zones.



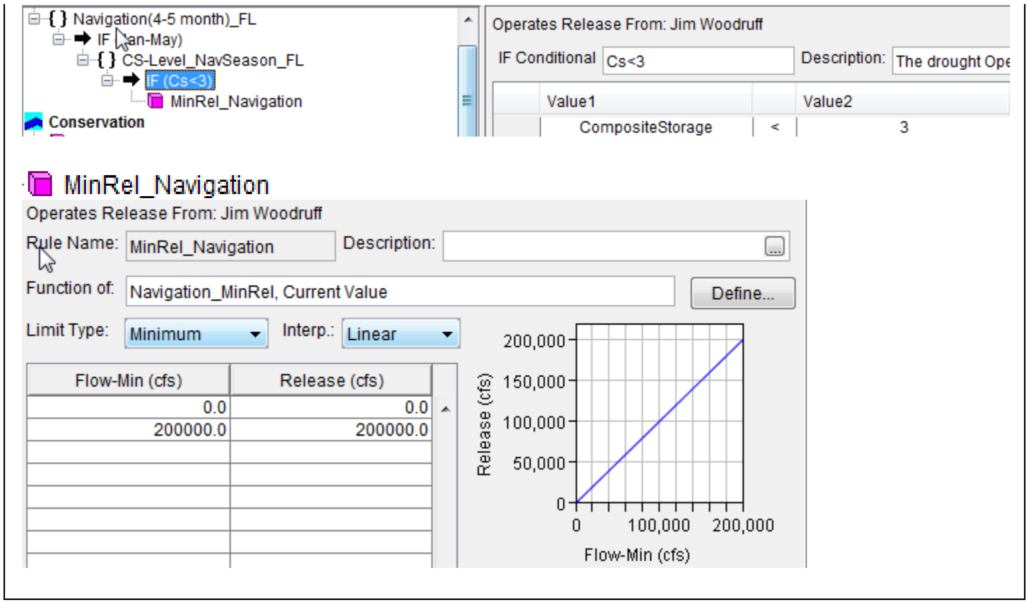


Figure E.34 Release Rules for *Navigation (4-5month)_FL*

2. Florida Basin Inflow

The RIOP method of calculating basin inflow does not consider large depletions from water consumption and reservoir evaporation.
Florida proposed Revised Basin Inflow (RBI) calculation includes depletions used in the reservoir model, in order to better represent "true" basin inflow.

RBI estimates depletions according to three climatological classifications of years (Wet, Normal, and Dry), as shown in Table E.08. Depletions used in Corps model include municipal and industrial demands, agricultural demands, and Federal reservoir evaporation which are defined for given month and type of year and shown in Table E.09.

Table E.08 Types of Years

1939	N	1958	W	1977	N	1996	N
1940	N	1959	N	1978	N	1997	N
1941	D	1960	N	1979	N	1998	N
1942	N	1961	N	1980	N	1999	D
1943	N	1962	N	1981	D	2000	D
1944	W	1963	N	1982	N	2001	N
1945	N	1964	W	1983	N	2002	N
1946	W	1965	W	1984	N	2003	W
1947	W	1966	N	1985	N	2004	N
1948	W	1967	N	1986	D	2005	N
1949	W	1968	D	1987	N	2006	D
1950	N	1969	N	1988	D	2007	D
1951	D	1970	N	1989	N	2008	N
1952	N	1971	W	1990	D	2009	N
1953	W	1972	N	1991	W	2010	N
1954	D	1973	W	1992	N	2011	D
1955	D	1974	N	1993	N	2012	D
1956	D	1975	W	1994	W		
1957	N	1976	N	1995	N		

W=Wet Years, N=Normal Years, D=Dry Years

Table E.09 Summary of depletions (cfs) to basin inflow upstream of Woodruff Dam used in Florida Basin Inflow

	Municipal and Industrial				Agriculture				Reservoir Evaporation				Total			
	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years
Jan	334	300	331	312	1	1	0	1	-183	-279	-415	-273	152	22	-85	40
Feb	302	263	295	276	23	3	0	7	-78	-159	-168	-141	246	107	127	142
Mar	345	254	257	276	94	41	31	53	153	-39	-197	-12	592	257	92	316
Apr	453	332	317	359	212	103	83	126	567	389	194	408	1231	825	594	883
May	615	457	340	480	586	344	292	395	672	573	338	569	1873	1374	970	1444
Jun	715	494	406	536	793	439	368	514	666	485	329	509	2173	1419	1104	1559
Jul	700	525	382	550	903	587	506	651	477	387	-61	356	2080	1499	827	1557
Aug	710	532	429	562	955	578	486	658	484	409	321	416	2149	1519	1236	1634
Sep	592	500	485	520	672	328	259	401	418	358	478	386	1682	1186	1222	1307
Oct	552	466	461	486	251	130	105	156	316	315	265	310	1119	912	831	951
Nov	435	378	388	392	192	90	70	112	33	-128	66	-67	660	339	525	437
Dec	399	337	358	354	168	79	62	98	-130	-186	-63	-158	437	230	356	293
Average	514	404	371	426	406	228	180	266	284	179	91	193	1204	811	652	885

Source: USFWS Biological Opinion May 22, 2012

3. Florida Flow Target

The operational requirements for Florida concept is represented in Table E.10. The *Florida Flow Target* rule establishes minimum outflows from Jim Woodruff as a function of composite storage, and basin inflow. The objective is to get Chattahoochee flows as close as possible to natural flows. The release trigger based on RBI instead of current Basin Inflow that includes net consumption in the basin above Jim Woodruff. A set of daily minimum flow are based on historic exceedance values that vary with season, composite storage zone and inflow conditions; dry or normal/wet. An additional release amount of 50% of available RBI over the minimum release is added to the minimum. Additional releases are not required when composite storage is in the drought zone (still under development at the time public comments were received). There are no additional rules for minimum flow reductions during drought operations. Minimum flows are simply lower for lower composite storage zones. When composite storage is in higher zone, minimum flows are higher.

Table E.10 Florida Flow Target

<table>
<tr><th rowspan="2">If Composite Conservation Storage-P7 is:</th><th rowspan="2">And if RBI-P7 is in:</th><th colspan="2">The average flow release-U7 is:</th></tr>
<tr><th>Minimum Flow</th><th>Plus additional Flow</th></tr>
<tr><td rowspan="2">Zone 1 or 2</td><td>Mid to High range</td><td>80% exceedance-U7</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td>Low range</td><td>85% exceedance-U7</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td rowspan="2">Zone 3 or 4</td><td>Mid to High range</td><td>90% exceedance-U7 with a minimum of 6,000 cfs</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td>Low range</td><td>95% exceedance-U7 with a minimum of 5,000 cfs</td><td>Mar-Nov: 50% of any RBI-P7 that exceeds minimum flow
Dec-Feb: No additional release required.</td></tr>
<tr><td>EDO</td><td>All Conditions</td><td>99% exceedance-U7 with a minimum of 5,000 cfs</td><td>No additional release required except 50% of storm pulses under certain conditions*</td></tr>
<tr><td colspan="4">*Conditions when 50% of storm pulses are released are under review and will be include at a later time.

Terms: P7=for the last seven days;U7=for the upcoming 7 days; RBI= revised Basin Inflow
Mid to High range=>75% exceedance of 7-day rolling average unimpaired flow(1939-2008);
Low range=<75% exceedance of 7-day rolling average unimpaired flow(1939-2008)</td></tr>
</table>

The RBI-P7 is classified as 'Mid to high range' or 'Low range'. The 75% exceedance of the 7-day rolling average unimpaired flow (1939-2008) is used as the threshold; if greater than 'Mid to high range' if less than 'Low range'. The daily flow range criteria is shown in Figure E.35.

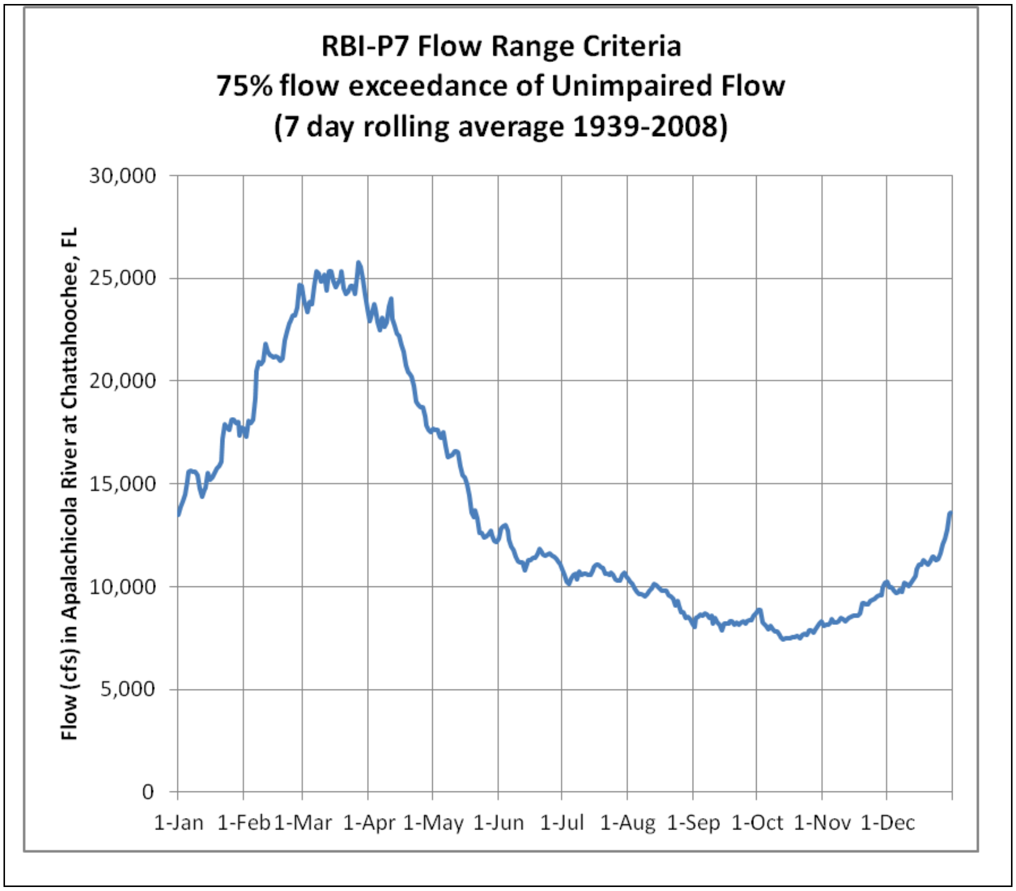


Figure E.35 Florida Flow Target-Flow range criteria

The set of minimum daily flows based on historic exceedance values are as follows;

80% exceedance pre-Buford Dam 1923-1955
85% exceedance pre-Buford Dam 1923-1955
90% exceedance pre-West Point Dam 1975-2008 (with 6,000 cfs min)
95% exceedance pre-West Point Dam 1975-2008 (with 5,000 cfs min)
99% exceedance pre-West Point Dam 1975-2008 (with 5,000 cfs min)

The daily minimum values are shown in Figure E.36.

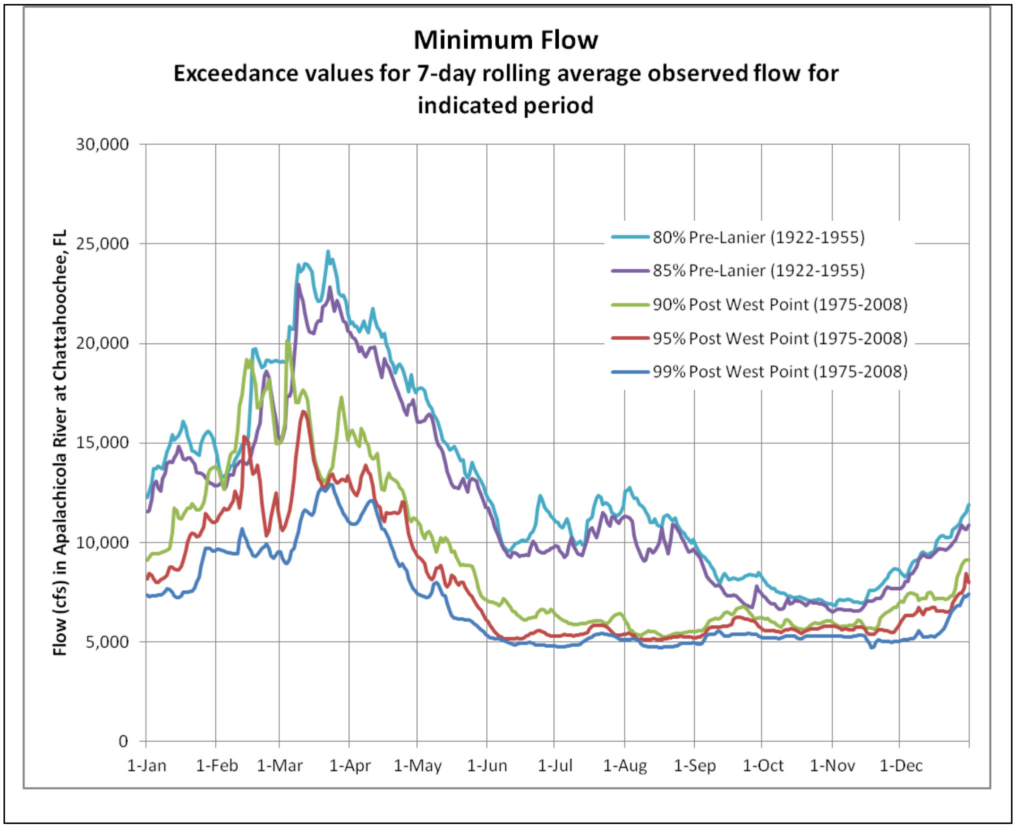


Figure E.36 Florida Flow Target-Daily Minimum Flow

4. *Florida Ramping Rate*

Table E.11 shows the proposed ramping rate for Orange operation set for flows <30,000 and > 8,000 more restrictive when compared to NoAction RIOP-Falling Ramp Rate PA2 rule. Fall rate for flows in excess of power capacity up to 30,000 cfs restricted to 0.5 ft/day. Fall rate for flows in range of 8,000 to 16,000 cfs restricted to 0.25 - 0.5 ft/day. Ramping rate of 0.25 ft/day will continue while in Zone 4 and in Extreme Drought Operations Zone. There will be no suspension of ramping rates under any conditions.

Table E.11 Florida Ramping Rate

Flow range (cfs)	Maximum fall rate (ft/day)
>30,000	No ramping restriction
Exceeds powerhouse capacity(~16,000) and <=30,000*	0.5
Within powerhouse capacity(16,000) and >8,000*	0.25 to 0.5
Within powerhouse capacity(16,000) and <=8,000*	0.25
*Including implementation in CCS Zone 4	

The *Florida Ramping Rate* rule applies in the conservation zones, at priority less than *Navigation (4-5 month) _FL.*

D. *Peach* Operation Set

The Peach operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to Navigation, Georgia Basin Inflow, Georgia Flow Target, and Suspend Ramping Rate after Pulse Flow. Figure E.37 shows a set of operational rules specified for each zone that reflects the operation set named “Peach”.

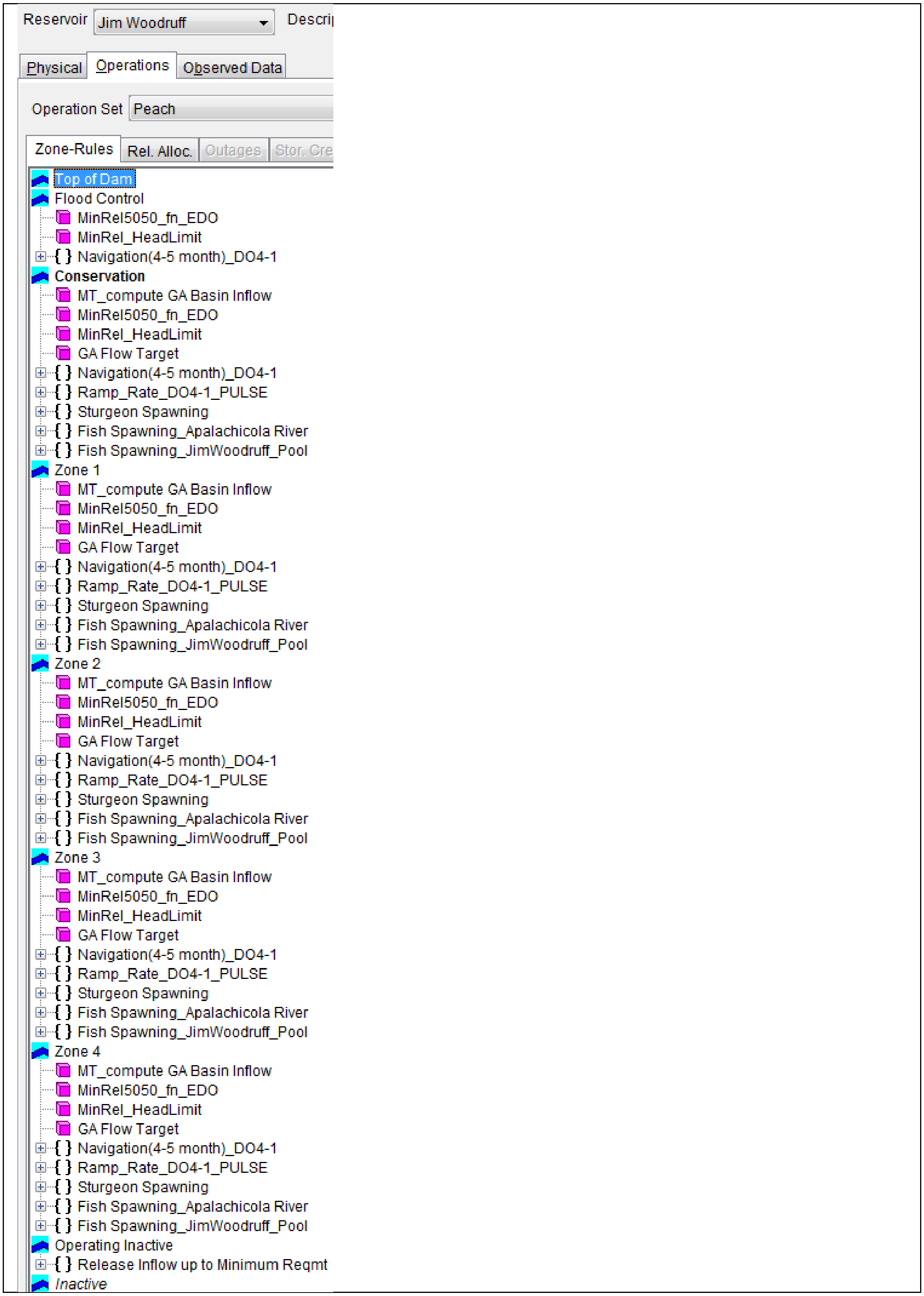


Figure E.37 Reservoir Editor- Network 2014: Operations Tab – Peach OpSet – Zones and Rules

"MT_compute GA Basin Inflow" is a zero minimum flow rule as shown in Figure E.38. This is a modeling technique to trigger "GABI_FMA7" state variable which calculate Georgia Basin Inflow. This state variable is needed by "GA_FlowTarget" state variable which calculates "GA Flow Target" rule. So, it has to be computed first to be used by "GA_FlowTarget" state variable.

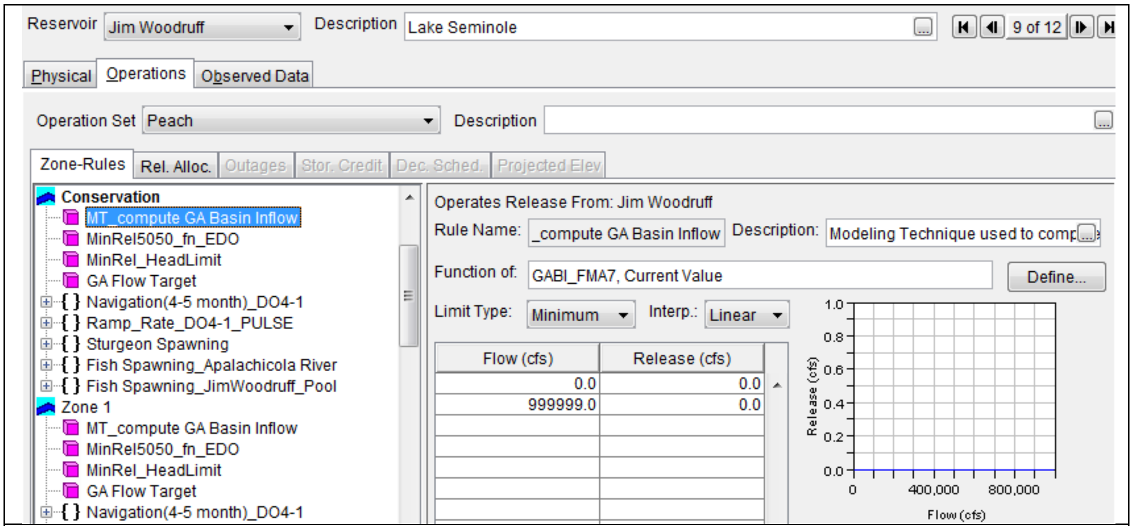


Figure E.38 MT_compute GA Basin Inflow rule

1. *Navigation (4-5 month) _DO4-1*

Navigation operation rules were added to the current operation set, to model the feasibility of a five month navigation season from January through May. This operation rule is the same as navigation rule defined in Silver operation set and is described in Figure E.19 and Figure E.20.

2. *Georgia Basin Inflow*

Basin inflow is defined the same as NO-Action for Georgia alternative except that it does not consider the lagging in the basin inflow computation. The formula provided is listed below:

Basin Inflow = Chattahoochee River flow + Lanier change in storage + West Point change in storage + WF George change in storage + Jim Woodruff change in storage

3. *Georgia Flow Target*

The operational requirements for Georgia alternative is represented in Table E.12. The *Georgia Flow Target* rule establishes minimum outflows from Jim Woodruff as a function of month, composite storage, and basin inflow. The intent of the release rules are to

- Target the highest amount of sustainable spawning habitat with the most economic use of storage
- Target the best availability of sustainable flood plain connectivity the Gulf sturgeon spawning period (March-May)
- Link the amount of preferred mussel habitat with stage and flow by using the Corps' bathymetric data of the Apalachicola River
- Design release rules to maximize the amount of mussel habitat

Table E.12 Georgia Flow Target

Months	Total storage in Reservoirs	Basin Inflow(BI) (cfs) or other conditions	State Line Flow (SLF) (cfs)	Basin Inflow to be stored (cfs)
March	Zone 1,2, and 3	NA	>=6,500	Entire or partial BI above SLF, subject to available Storage capacity
April 1-May 31	Zone 1,2, and 3	Cumulative BI in February and March > 2.45 million acre-feet	Maintain Q=min(10,500, min(observed moving 30-day flow))	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if BI>=10,500 If BI<10,500 and >= 5,000 If BI <5,000	>= 10,500 >= BI >= 5,000	
In sub-period April 16-April 30		Lanier>1066' , and West Point>632' , and Walter F George >187'	Maintain Q=min(22,500,max(10,500, min(observed March 17-April 15 daily flow)))	Entire or partial BI above SLF, subject to available Storage capacity
June-Nov	Zone 1,2, and 3	BI>= 10476 & previous seven day's Chattahoochee gage flow<5100	>= High Pulse flow (June 14,850, July 15,500, August 14,400, September 11,200, October 10,100, November 10,500), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		BI>= 7181 and < 10476 & previous seven day's Chattahoochee gage flow<5100	>= Small Pulse flow (June 11,600, July 11,500, August 11,100, September 8,620, October 7,420, November 7,980), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		Other Situation	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	>=4,500	Entire or partial BI above 5,000 subject to available Storage capacity

The following is a detailed description of the flow target by season.

March 1 through March 31
Georgia Flow Target maintains a minimum flow requirement in the Apalachicola River at Chattahoochee, Florida for March of 6,500 cfs. March historically has been the wettest month in the ACF Basin, and monthly average flow in the Apalachicola River at the Chattahoochee gage during March is expected to exceed 6,500 cfs.

April 1 through May 31
Conserve system storage to meet water supply and other authorized reservoir purpose the observation of February and March flow provides a good basis for determining subsequent flow and a sustainable level of spawning season habitat. Georgia Flow Target use cumulative February and March basin inflow (BI) to determine if the ACF Basin is likely to be under drought conditions. When cumulative BI for February and March is higher than 2.45 million acre-feet, the basin is considered to be under normal spring hydrologic conditions. When cumulative BI is lower than 2.45 million acre-feet, the basin is likely to be either in drought or approaching drought conditions. When the basin is under normal spring hydrologic conditions, we set release into the Apalachicola River at the lower of 10,500 cfs or the moving minimum of the previous 30 days. A 10,500 cfs flow provides about 85% of all the available sturgeon spawning habitat at the amount of inundation specified in the 2012 Biological Opinion. When the basin is under likely drought conditions, as determined by the cumulative BI, release into the Apalachicola River is set at 10,500 cfs when BI is higher than 10,500 cfs, or BI if it is lower than 10,500 cfs, but not lower than 5,000 cfs. This assures that a continuous 30-day inundation of a large portion of the spawning habitat is achieved.

Sub-period April 16 through April 30
1. When Lanier elevation is above 1066 feet, West Point elevation is above 632 feet, and Walter F. George is above 187 feet, the Georgia Contemplation uses the following procedure to determine releases to support flood plain connectivity:
a. Determine the minimum level of flow that has been sustained in the previous 30 days
(March 17 through April 15);
b. Compare this sustained flow with 10,500 cfs, and take the larger one; and c. Compare the flow obtained in step b with 22,500 cfs, and take the lower one as the level of flow to be sustained for the sub-period.
2. When Lanier, West Point, or Walter F. George is below the elevation levels specified above, the above support of flood plain connectivity will not be provided.
This approach makes good use of naturally-higher flow in the first half of April and provides limited support from storage in the second half of April to achieve sustainable flow support for flood plain connectivity for up to 30 days

June 1 through November 30

The Georgia Flow Target maintains a 5,000 cfs minimum flow requirement as the base flow for the non-spawning season. When BI rises above the 25th percentile for the period, roughly 7,200 cfs, a pulse flow lasting one day and corresponding to the 25th percentile daily flow can be made. Table E.13 shows the values for Georgia Low Pulse Flow.

Table E.13 Georgia Low Pulse Flow

Month	25^{th} Percentile Flow Pulse (cfs)
June	11600
July	11500
August	11100
September	8620
October	7420
November	7980

When BI rises above median for the period, roughly 10,500 cfs, the Georgia Flow Target could provide a pulse flow lasting one day and corresponding to median daily flow. Table E.14 shows the values for Georgia Low Pulse Flow.

Table E.14 Georgia High Pulse Flow

Month	Median Flow Pulse (cfs)
June	14850
July	15500
August	14400
September	11200
October	10100
November	10100

FWS has mentioned benefits of having pulse flows in the non-spawning season (June through November), including elevating dissolved oxygen, removing debris, and providing food sources to living organisms. This 1-day pulse flow attempts to provide such benefit.

Using one-day BI better enables triggering of higher pulses than 7-day average BI with an interval of seven days between any two consecutive pulses. A second pulse flow would not take place until seven days after the previous one and the 1-day BI meets the above stated conditions,

December 1 through February 28

The Georgia Flow Target only minimum flow requirement in the Apalachicola River at the Chattahoochee gage is 5,000 cfs. Any BI beyond this minimum flow requirement is stored to replenish system storage, to the extent possible.

4. *Suspend Ramping Rate after Pulse Flow*

The Peach operation set suspends Ramping Rate after pulse flow. The state variable *Pulse* is shown in Figure E.39.This state variable is described in

Appendix H. If flow conditions are met and the state variable equals 1, then *BI-Falling Ramp Rate* rule is used instead of *RIOP-Falling Ramp Rate* rule. Since the river rises quickly, there is little time for mussels to migrate up. Consequently, the river will fall at the rate of the 1-day basin inflow.

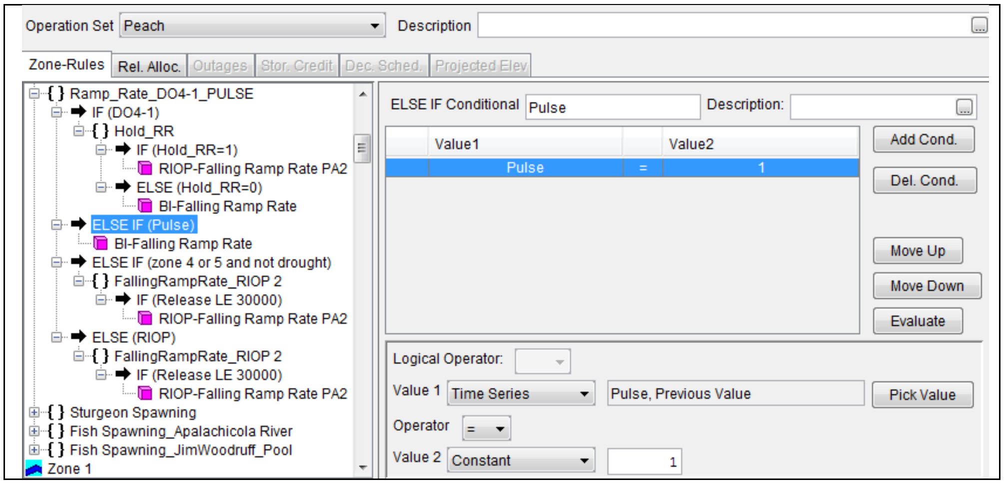


Figure E.39 Conditional Block for *Ramp_Rate_DO4-1_PULSE* Rule

5. Minimum Release Based on EDO

The Peach operation set applies its own version of the RIOP minimum release, called "*MinRel5050_fn_EDO*", at highest priority to the flood control zone and all conservation zones.

E. *Blue* Operation Set

The Blue operation set retains all the rules and settings from Silver, with rules added to accommodate measures relating to Navigation, FWS Flow Target, and Suspend Drought Operation at Zone 3. Figure E.40 shows a set of operational rules specified for each zone that reflects the operation set named "Blue".

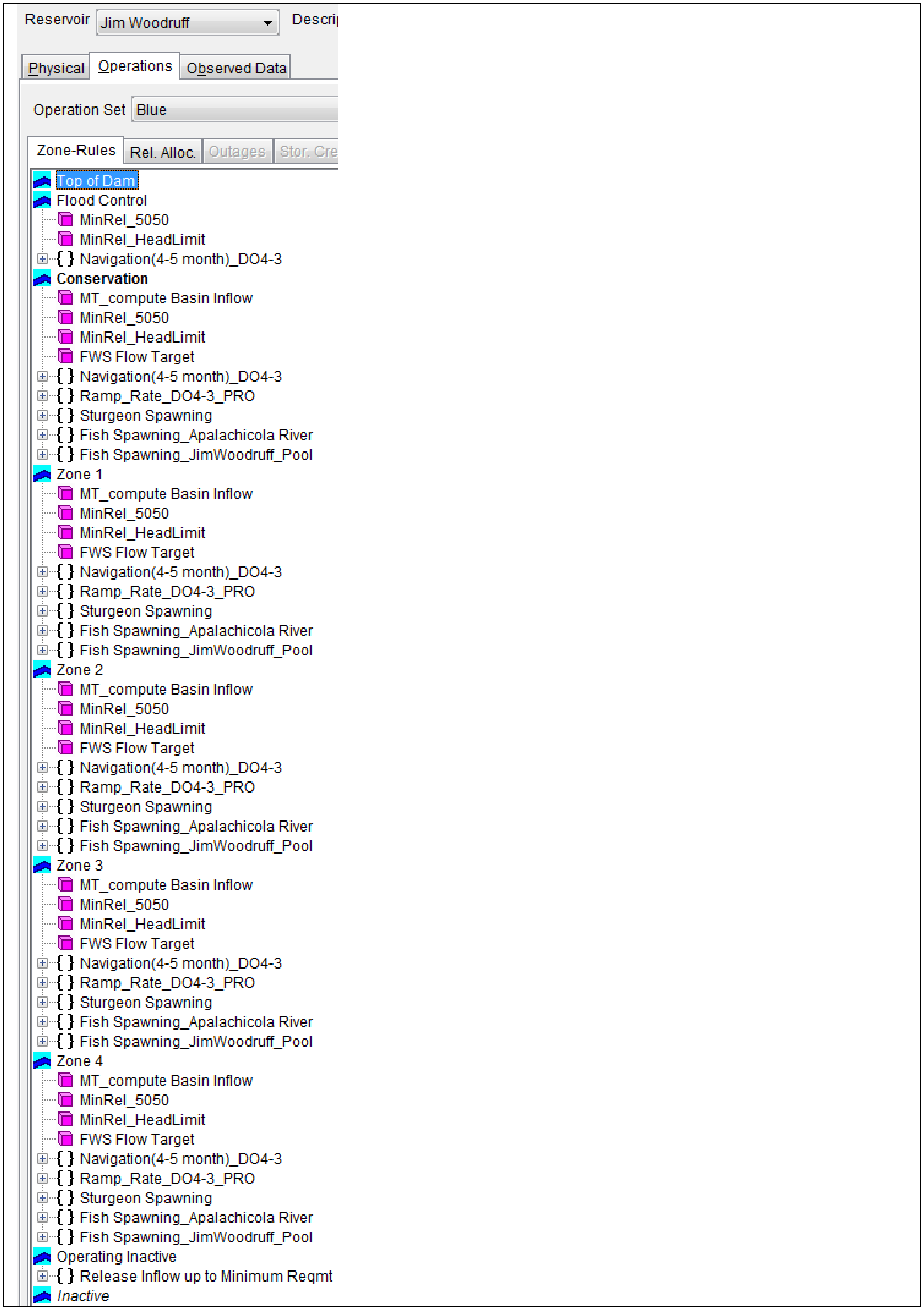


Figure E.40 Reservoir Editor- Network 2014: Operations Tab – Blue OpSet – Zones and Rules

"MT_compute Basin Inflow" is a zero minimum flow rule as shown in Figure E.41. This is a modeling technique to trigger "BI_FMA7" state variable which calculate Basin Inflow. This state variable is needed by "FWS_FlowTarget" state variable which calculates "FWS Flow Target" rule. So, it has to be computed first to be used by "FWS_FlowTarget" state variable.

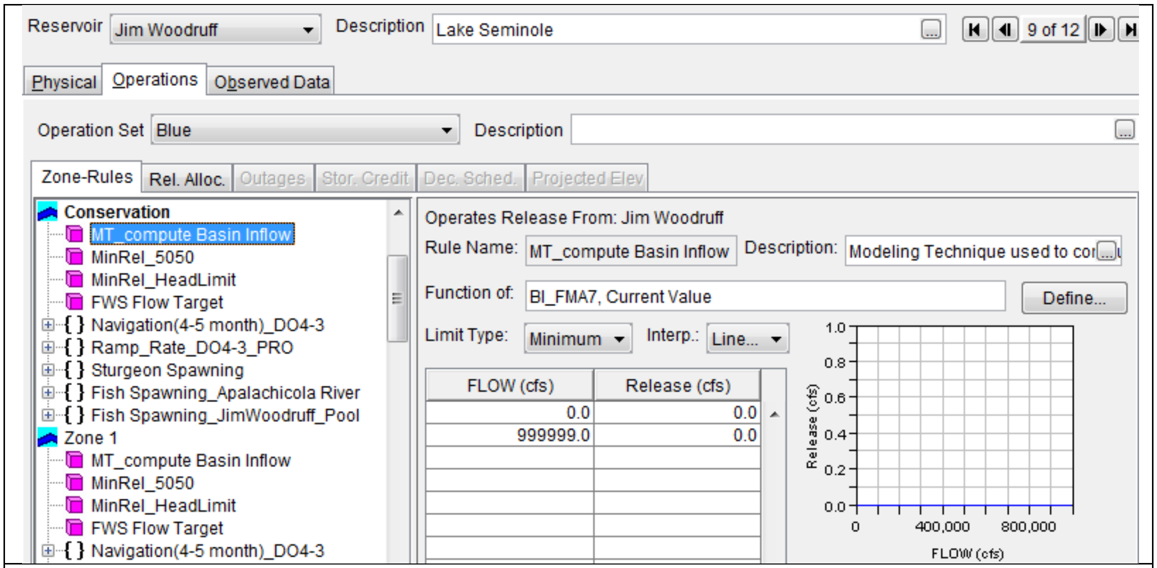


Figure E.41 MT_compute Basin Inflow rule

1. ***Navigation (4-5) month_DO4-3***

   The "*Navigation(4-5 month)_DO4-3*" rule closely resembles the navigation rule from the Silver operation set, except using a different definition of the drought condition (i.e., drought condition lifted at composite storage level 3). This revised drought condition is represented by state variable Drought_Ops_4_3, as described in Append H. . The description of *Navigation(4-5) month_DO4-3* is shown in Figure E.42.

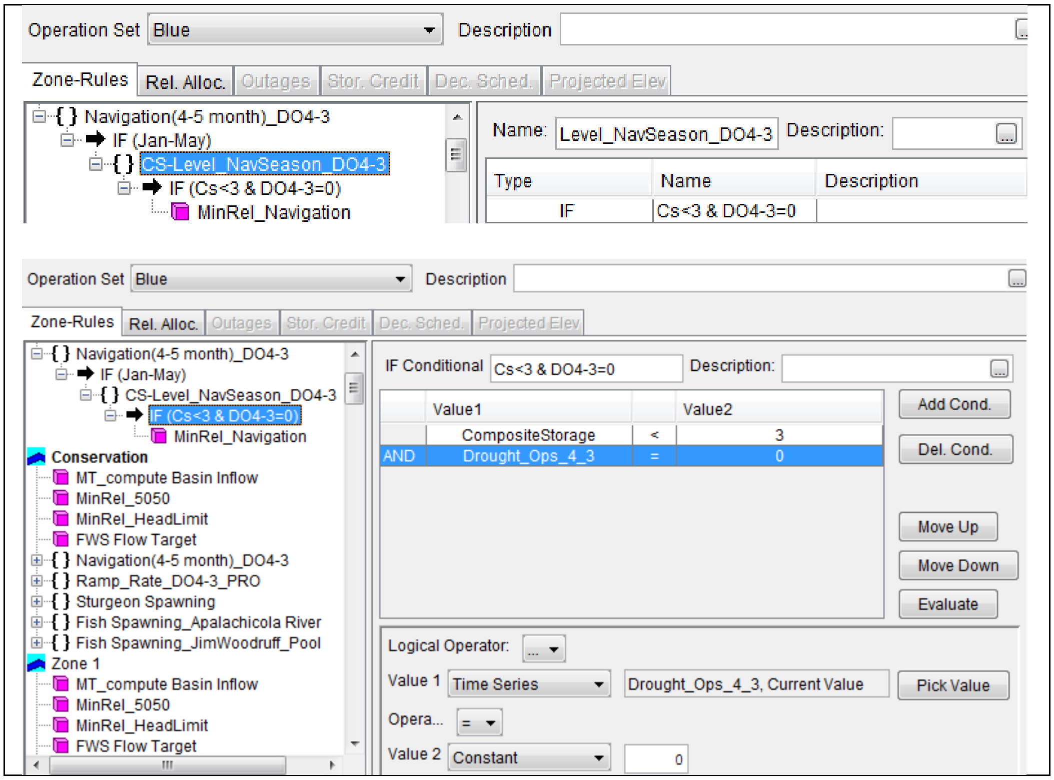


Figure E.42 Release Rules for *Navigation (4-5month)_DO4-3*

2. *FWS Flow Target*

The operational requirements and logic for FWS alternative is represented in Figure E.43. The intent of the release rules are to

- Provide a reasonable degree of flow support into the Apalachicola River for the fish and wildlife purpose of the ACF projects at levels greater than 5,000 cfs.
- Minimize the number of periods per year of low flows (<10,000 cfs), which directly adversely affect fish and wildlife or otherwise limit their populations.
- Maximize floodplain connectivity, especially in the spring spawning season

If 7-day basin inflow exceeds the month/zone target, releases the target flow from Jim Woodruff dam. All basin inflow exceeding the target is available for storage, subject to flood control roles. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Jim Woodruff dam is the greater of a.) the month/zone minimum or b.) basin inflow plus the zone augmentation.

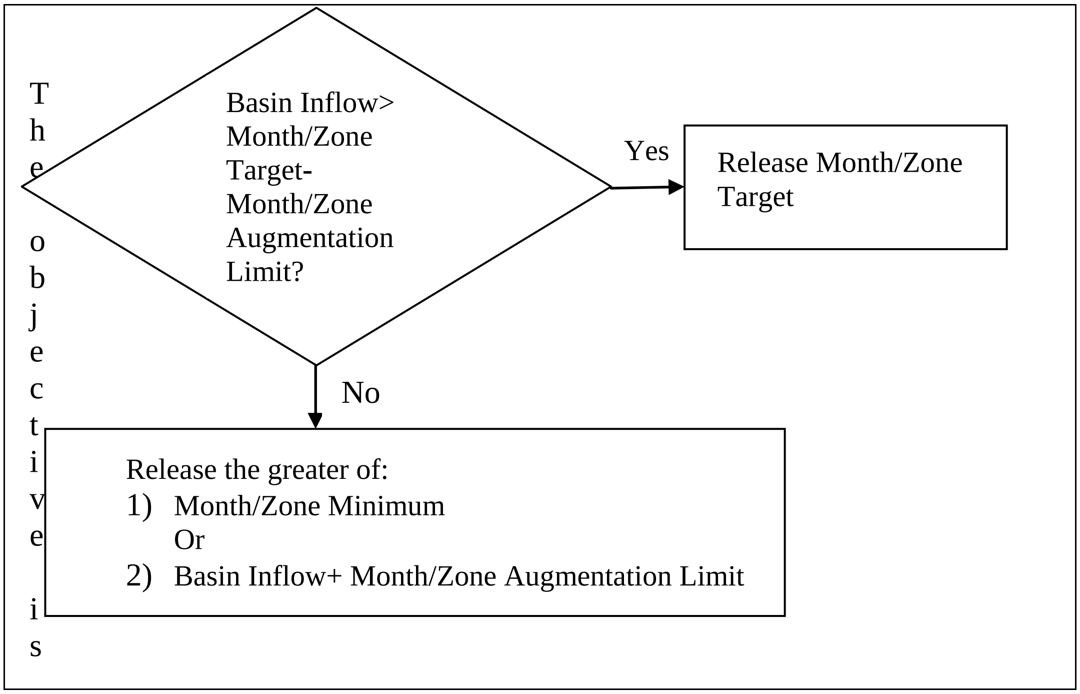


Figure E.43 FWS Flow Target

The objective is operate the system as a whole for target and minimum releases from Woodruff Dam, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates. Target and minimum flows are month and zone-specific. Target flows are subject to zone-specific augmentation limits. Action Zones, 1 through 4, are defined for Lanier, West Point, and George, relative to the authorized top and bottom of the conservation pool. Release decisions for the system as a whole (i.e., from Woodruff Dam) are based on the current composite storage zone, month, and the previous 7-day basin inflow. Each project makes daily releases to meet local operating requirements or to replenish storage in the next project downstream, whichever is greater, so that all projects remain in the same operating zone.

FWS Target Flows, Augmentation Limits, and Minimum Flows are represented in Table E.15, Table E.16, and Table E.17 respectively. The FWS flow target rule applies in the conservation zones, at a priority lower than headlimnits release, but higher than prolonged flow ramp rate.

Table E.15 FWS Target Flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	*Zone 1	Zone 2	Zone 3	Zone 4
Jan	19,000	17,000	10,000	5,000
Feb	21,000	19,000	10,000	5,000
Mar	21,000	19,000	14,000	5,000
Apr	21,000	19,000	14,000	5,000
May	19,000	17,000	10,000	5,000
Jun	14,000	14,000	10,000	5,000
Jul	12,000	10,000	10,000	5,000
Aug	12,000	10,000	10,000	5,000
Sep	10,000	10,000	10,000	5,000
Oct	10,000	10,000	10,000	5,000
Nov	10,000	10,000	10,000	5,000
Dec	10,000	10,000	10,000	5,000

Table E.16 FWS Augmentation Limits (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	2,000	0	1,000	0
Feb	4,000	2,000	2,000	0
Mar	4,000	2,000	3,000	0
Apr	4,000	2,000	3,000	0
May	2,000	4,000	2,000	0
Jun	2,000	2,000	1,000	0
Jul	2,000	2,000	1,000	0
Aug	2,000	2,000	1,000	0
Sep	0	1,500	1,000	0
Oct	0	1,500	1,000	0
Nov	0	1,500	1,000	0
Dec	0	1,500	1,000	0

Table E.17 FWS Minimum flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	17,000	17,000	5,000	5,000
Feb	17,000	17,000	5,000	5,000
Mar	17,000	17,000	8,000	5,000
Apr	17,000	17,000	8,000	5,000
May	17,000	10,000	8,000	5,000
Jun	12,000	8,000	5,000	5,000
Jul	10,000	7,000	5,000	5,000
Aug	10,000	7,000	5,000	5,000
Sep	10,000	6,000	5,000	5,000
Oct	10,000	5,000	5,000	5,000
Nov	10,000	6,000	5,000	5,000
Dec	10,000	8,000	5,000	5,000

Target and minimum flows during January to May are intended to provide for a 9 to 7 feet deep navigation channel while in zone 1 and 2.

3. Suspend Drought Operations at Zone 3

Drought operation definition is the same as NO-Action except the drought plan is suspended when the composite storage reaches a level above the top of Zone 4 (i.e., within Zone 3) as shown in Figure E.44. Note that composite storages are defined based on Revised Action Zones.

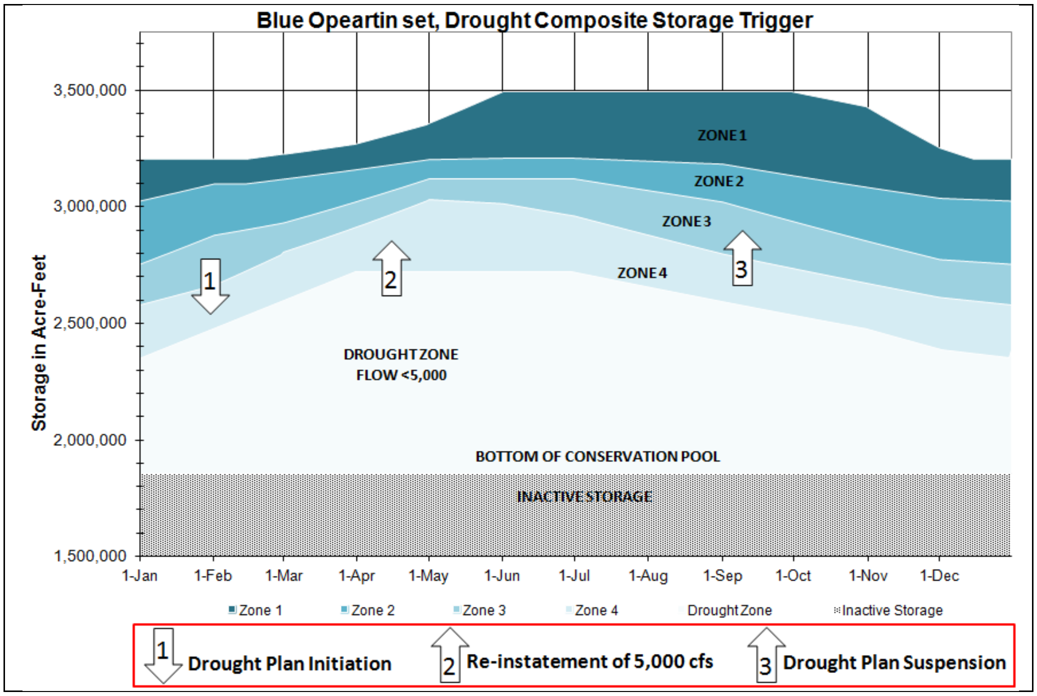


Figure E.44 Blue Operation Set-Drought Composite Storage Triggers

F. *Gold* Operation Set

The Gold operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to navigation, and Trigger Drought Operation at Zone 3. Figure E.45 shows a set of operational rules specified for each zone that reflects the operation set named “Gold”.

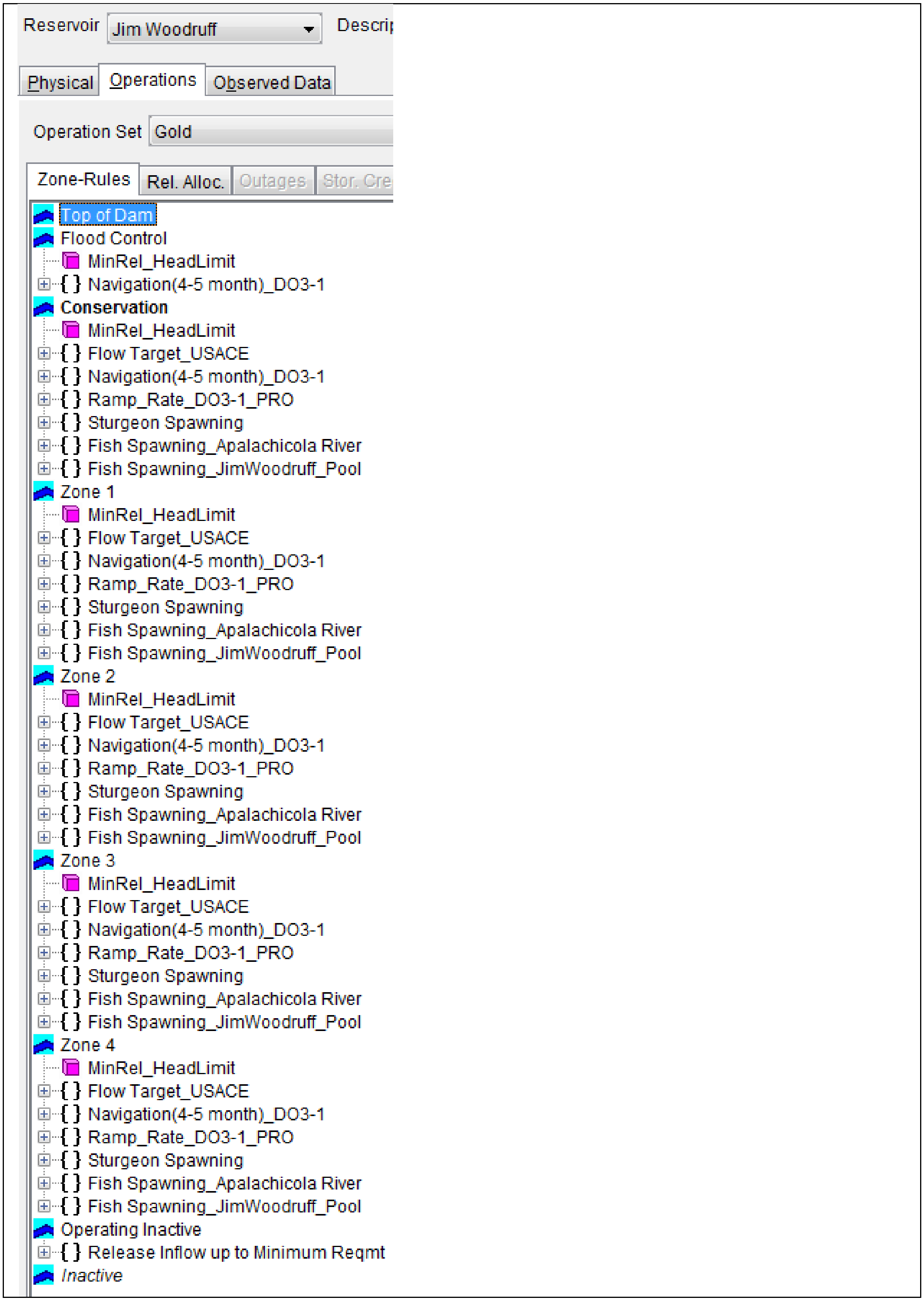


Figure E.45 Reservoir Editor- Network 2014: Operations Tab – Gold OpSet – Zones and Rules

1. Navigation (4-5) month_DO3-1

The "Navigation(4-5 month)_DO3-1" rule closely resembles the Navigation operation rule from the Silver operation set, except using a different definition of the drought condition (i.e., drought condition initiated if composite storage falls to level 3. This revised drought condition is represented by state variable Drought_Ops_3_1, as described in Append H. The description of Navigation(4-5) month_DO3-1 is shown in Figure E.46.

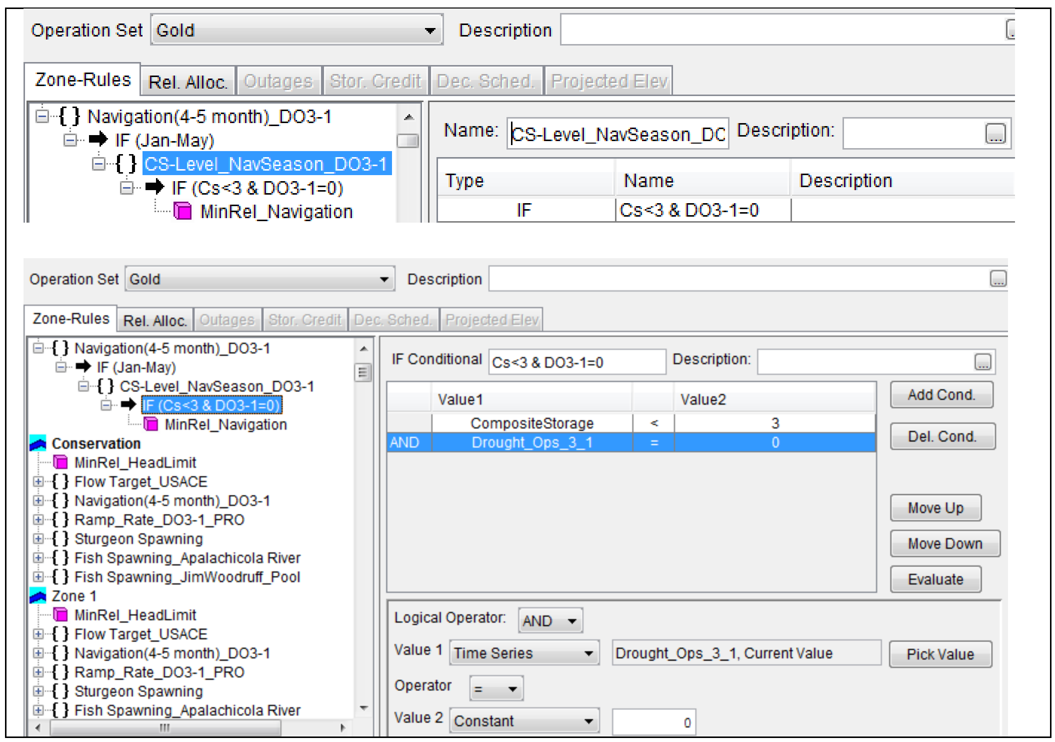


Figure E.46 Release Rules for *Navigation (4-5month)_DO3-1*Rule

2. Trigger Drought Operation at Zone 3

Drought operation definition is the same as NO-Action except the drought plan is "triggered" when composite storage falls below the bottom of Zone 2 into Zone 3 as shown in Figure E.47. Note that composite storages are defined based on Revised Action Zones.

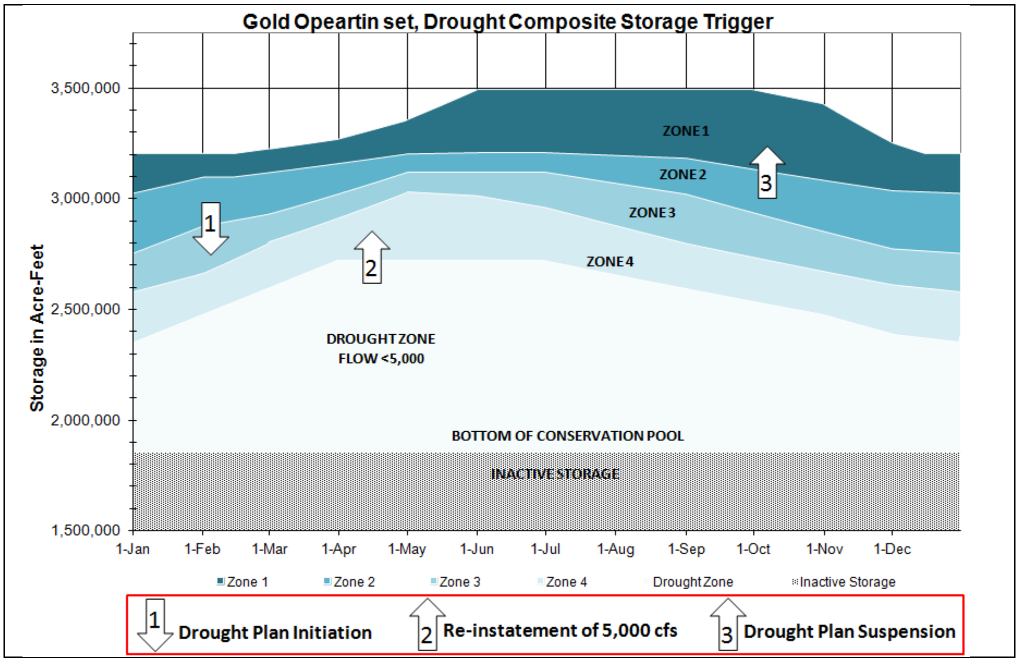


Figure E.47 Gold Operation Set-Drought Composite Storage Triggers

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix F – Flow-Thru Reservoirs:

Morgan Falls, Bartletts Ferry, Goat Rock, Oliver, and North Highlands

June 2014

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Appendix F – Flow-Thru Reservoirs

Table of Contents:

List of Tables:

List of Figures:

Flow-thru Reservoirs

I. Morgan Falls

A. Overview

Morgan Falls Dam is owned by the Georgia Power Company (GPC). It is located at river mile 312.6 near Roswell, Georgia. The project was constructed between 1903 and 1904. Morgan Falls Dam creates a narrow 673-acre impoundment named Bull Sluice Lake. GPC currently operates Morgan Falls Dam in a modified run-of-river mode for the primary purposes of power generation and domestic water supply for metropolitan Atlanta. GPC uses the very limited reservoir storage to the maximum extent possible to re-regulate flow releases from upstream Buford Dam during off-peak power periods. However, due to the very small storage capacity of the impoundment, GPC's ability to re-regulate inflow is limited.

The total hydraulic capacity of the powerhouse is approximately 5,500 cfs and the total generating capacity is 16.8 MW. The outlets consist of a spillway section 680 feet long with 16 radial tainter gates and a combined powerhouse and intake section.

Figure F.01 shows the location of Morgan Falls Reservoir as it is represented in the HEC-ResSim model.

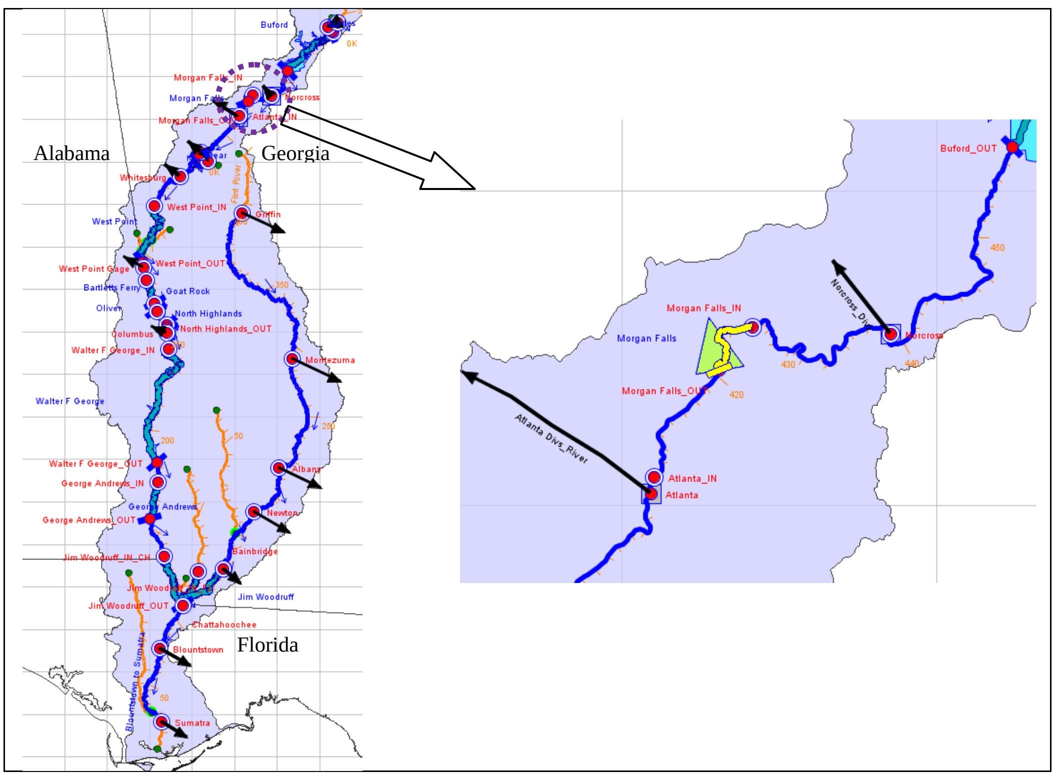


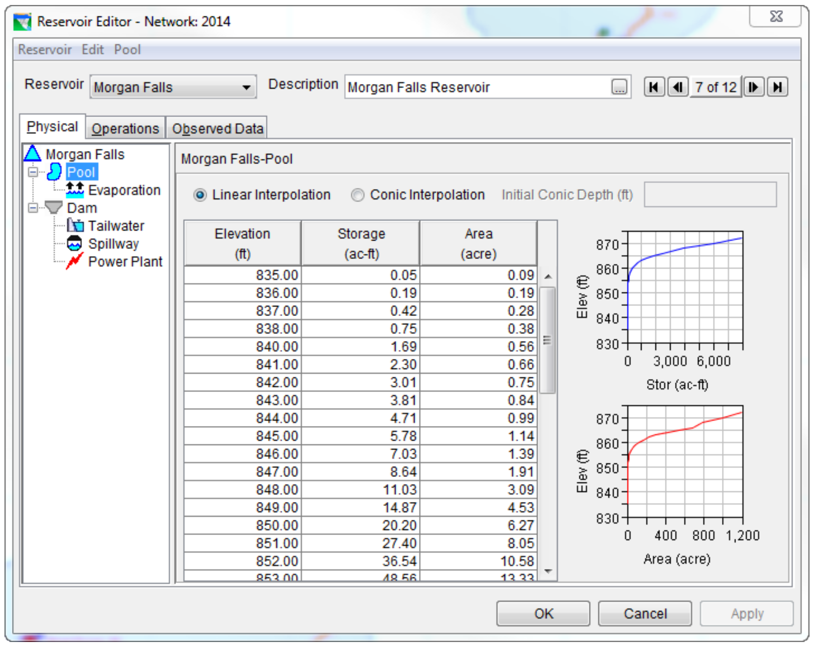
Figure F.01 HEC-ResSim Map Display Showing Location of Morgan Falls

Figure F.02 shows a photo of Morgan Falls Dam.

Figure F.02 Photo of Morgan Falls Dam

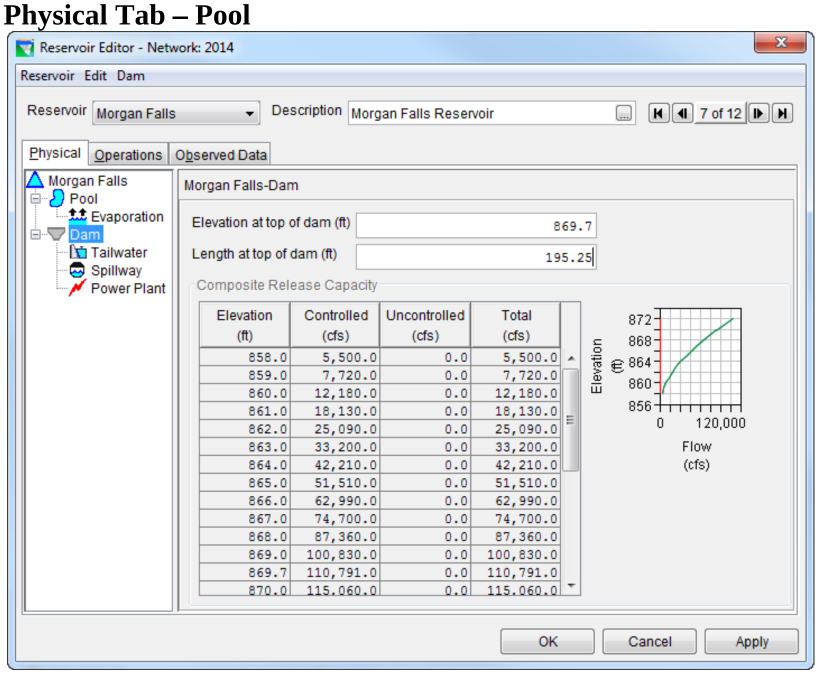
B. Physical Characteristics

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 Morgan Falls Reservoir in Figure F.03. Morgan Falls 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 all of the outlets as shown in Figure F.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
835.00	0.05	0.09
836.00	0.19	0.19
837.00	0.42	0.28
838.00	0.75	0.38
840.00	1.69	0.56
841.00	2.30	0.66
842.00	3.01	0.75
843.00	3.81	0.84
844.00	4.71	0.99
845.00	5.78	1.14
846.00	7.03	1.39
847.00	8.64	1.91
848.00	11.03	3.09
849.00	14.87	4.53
850.00	20.20	6.27
851.00	27.40	8.05
852.00	36.54	10.58
853.00	48.56	13.33

Figure F.03 Morgan Falls Reservoir Editor – Network 2014: Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
858.0	5,500.0	0.0	5,500.0
859.0	7,720.0	0.0	7,720.0
860.0	12,180.0	0.0	12,180.0
861.0	18,130.0	0.0	18,130.0
862.0	25,090.0	0.0	25,090.0
863.0	33,200.0	0.0	33,200.0
864.0	42,210.0	0.0	42,210.0
865.0	51,510.0	0.0	51,510.0
866.0	62,990.0	0.0	62,990.0
867.0	74,700.0	0.0	74,700.0
868.0	87,360.0	0.0	87,360.0
869.0	100,830.0	0.0	100,830.0
869.7	110,791.0	0.0	110,791.0
870.0	115,060.0	0.0	115,060.0

Figure F.04 Morgan Falls Reservoir Editor – Network 2014: Physical Tab – Dam

C. NOAction Operations

1. *Flow-thru* Operation Set

Table F.01 shows the definition of operational zones consisting of Top of Dam, Maximum Pool, and Conservation zone, as well as an Inactive zone.

Table F.01 Morgan Falls Zone Elevations for *Flow-thru* Operation Set

Morgan Falls	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Top of Dam	869.7
Maximum Pool	868
Conservation	866
Inactive	858

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

Figure F.06 shows a sequential release allocation approach specified for available outlets along Morgan Falls 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.

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

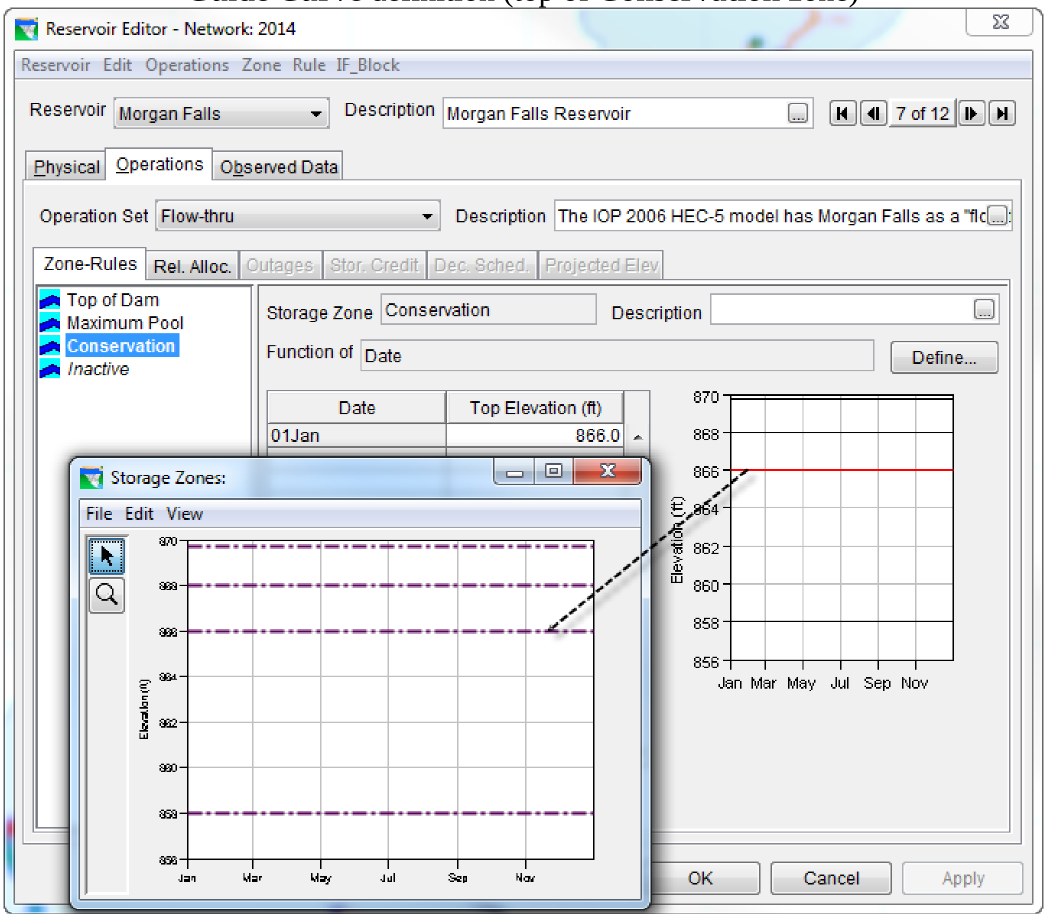


Figure F.05 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Guide Curve

Release Allocation:

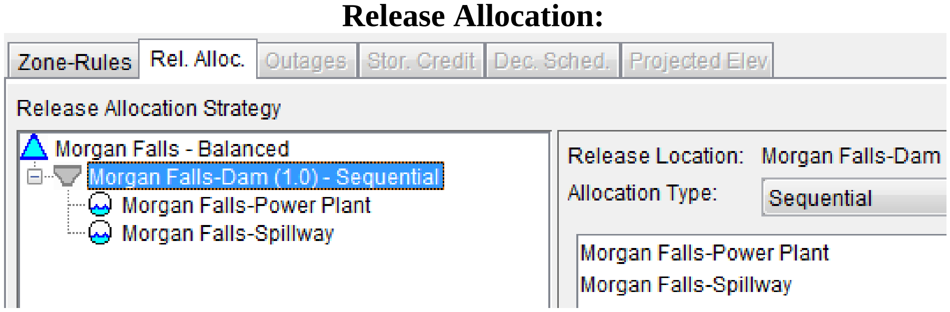


Figure F.06 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Release Allocation

Figure F.07 shows a set of operational zones that reflects the operation set named *Flow-thru*. The *Flow-thru* operation set 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.

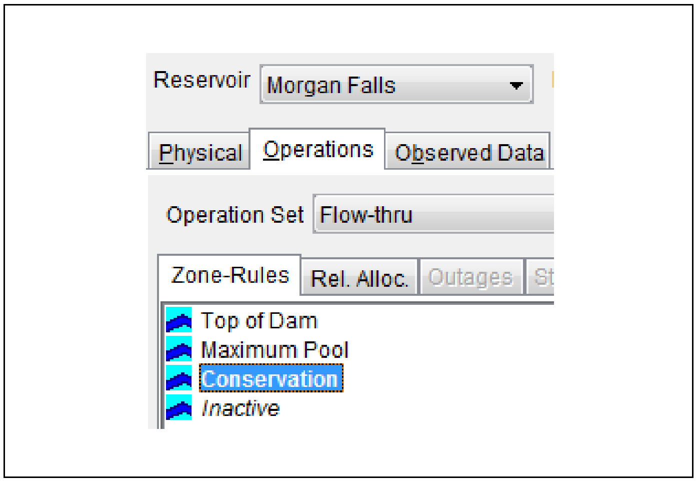


Figure F.07 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* – Zones

D. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for Morgan Falls is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

II. Bartletts Ferry

A. Overview

Bartletts Ferry Dam is operated by GPC and is located approximately 23 miles downstream of West Point Dam. West Point controls about 82 percent of the inflow into Bartletts Ferry. Only 18 percent of the water entering Bartletts Ferry originates from local inflows. The reservoir is currently operated at near full pond year-round, with no fall drawdown. Bartletts Ferry is normally operated with daily average fluctuations of about three quarters of a foot.

The original plant began producing power at a capacity of 15 MW. Since then the powerhouse has received additions and now the name plate capacity of Bartletts Ferry Powerhouse is 173 MW with a total hydraulic capacity of 24,200 cfs.

Figure F.08 shows the location of Bartletts Ferry Reservoir as it is represented in the HEC-ResSim model.

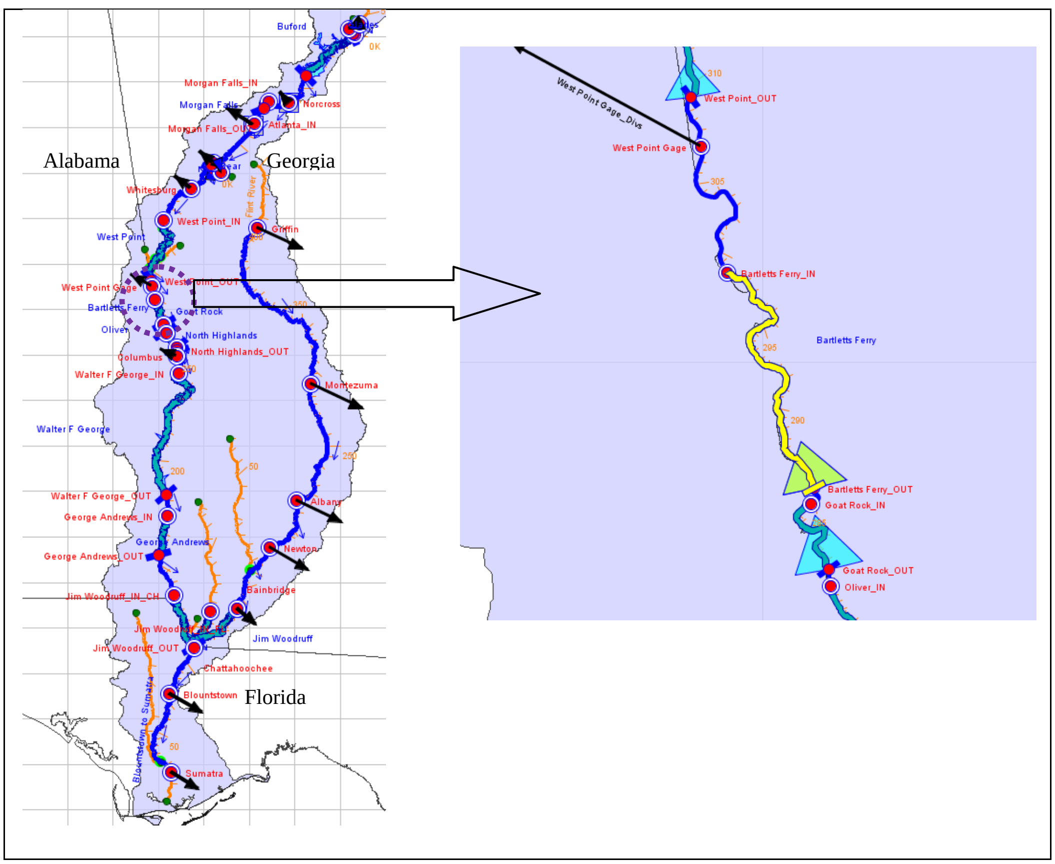


Figure F.08 HEC-ResSim Map Display Showing Location of Bartletts Ferry

Figure F.09 shows a photo of Bartletts Ferry Dam.

Figure F.09 Photo of Bartletts Ferry 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 Bartletts Ferry Reservoir in Figure F.10. Bartletts Ferry Dam consists of three types of outlets: (1) a controlled spillway; (2) a controlled outlet; 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 F.11.

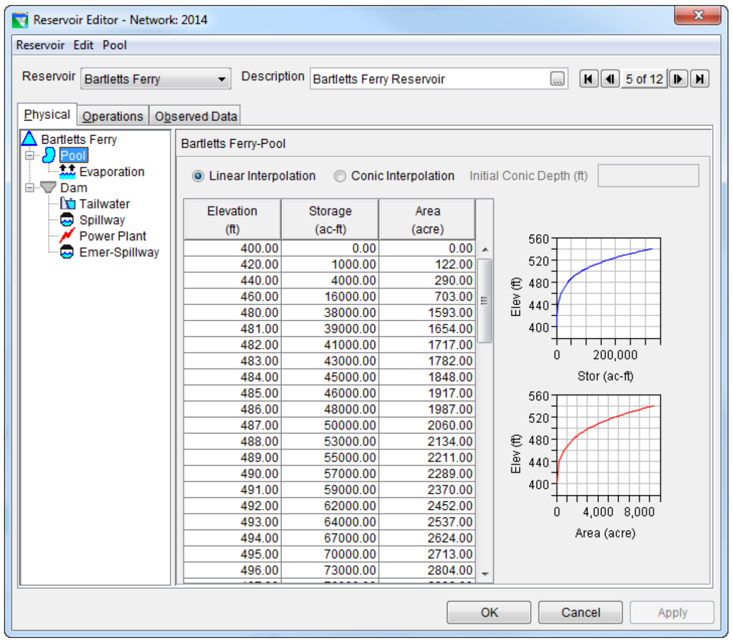


Figure F.10 Bartletts Ferry Reservoir Editor – Network 2014: Physical Tab – Pool

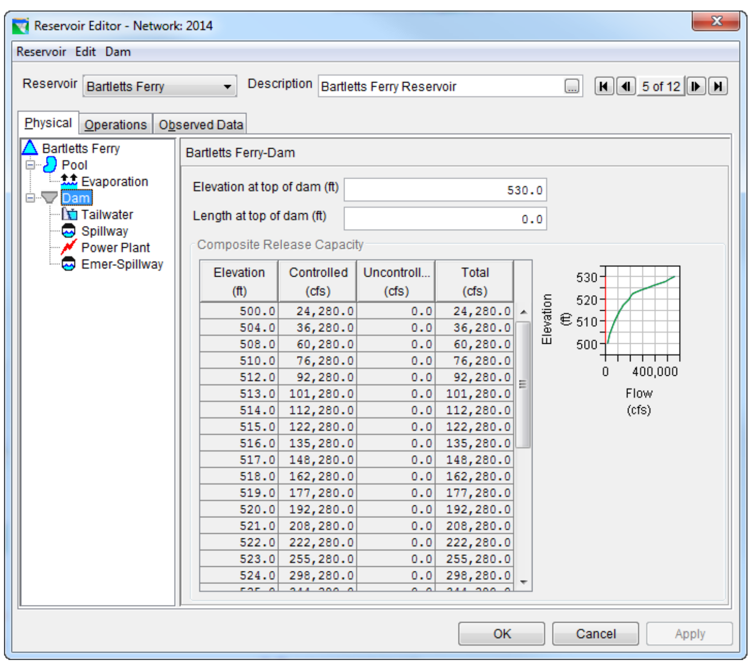


Figure F.11 Bartletts Ferry Reservoir Editor – Network 2014: Physical Tab – Dam

C. NOAction Operations

1. *Flow-thru* Operation Set

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

Table F.02 Bartletts Ferry Zone Elevations for *Flow-thru* Operation Set

Bartletts Ferry	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Top of Dam	530
Conservation	521
Inactive	510

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

Figure F.13 shows a sequential release allocation approach specified for available outlets along Bartletts 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 until it reaches release capacity, at which time the release goes through the controlled outlet.

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

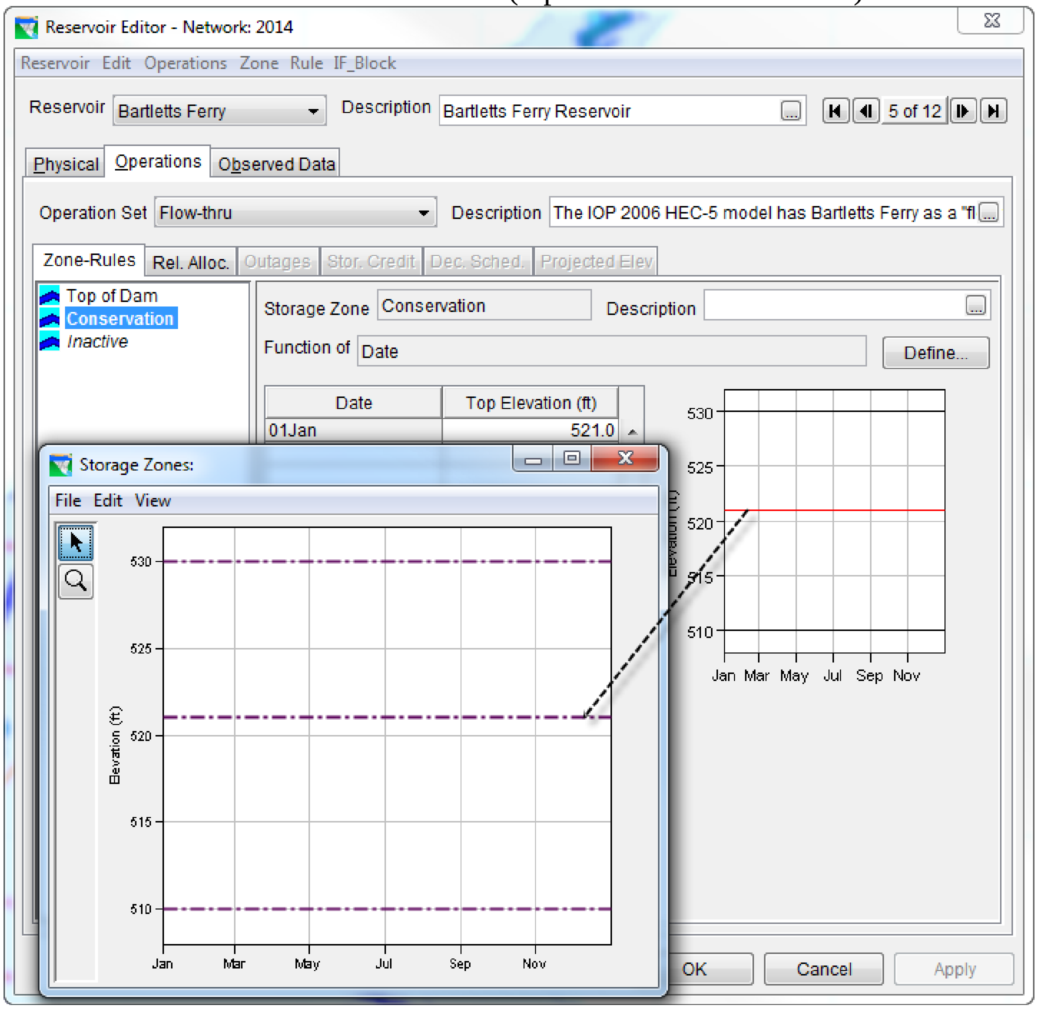


Figure F.12 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Guide Curve

Release Allocation:

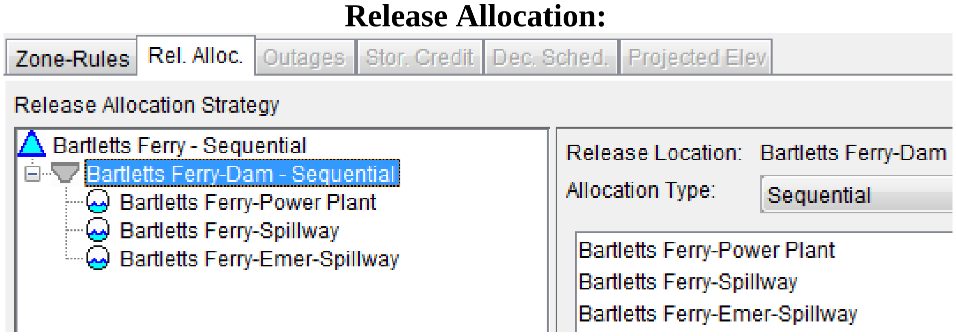


Figure F.13 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Release Allocation

Figure F.14 shows a set of operational zones that reflects the operation set named *Flow-thru*. The *Flow-thru* operation set 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.

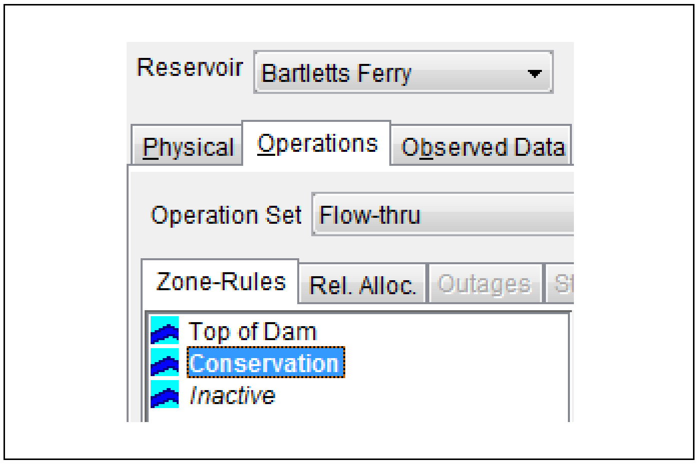


Figure F.14 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* – Zones

D. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for Bartletts Ferry is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

III. Goat Rock

A. Overview

Goat Rock Dam is owned by GPC. It is located at river mile 172.2 on the Chattahoochee River and lies within Harris County, Georgia and Lee County, Alabama. The dam was constructed in 1912 and received its name for the goats that were seen in the vicinity of the project jumping from rock to rock. The main purpose of the project is generation of hydro-electric power. Other purposes include water supply, recreation, and fish and wildlife. It is operated as a run-of-river project and therefore contains little to no storage.

The Goat Rock hydropower facility can be controlled remotely and is equipped with six horizontal generating units that are capable of producing 26,000 kilowatts of power. The 70 feet high concrete dam spans 1,434 feet across the river. The reservoir covers 1,050 acres of land at an elevation of 404 feet above sea level. There are approximately 25 miles of shoreline.

Figure F.15 shows the location of Goat Rock Reservoir as it is represented in the HEC-ResSim model.

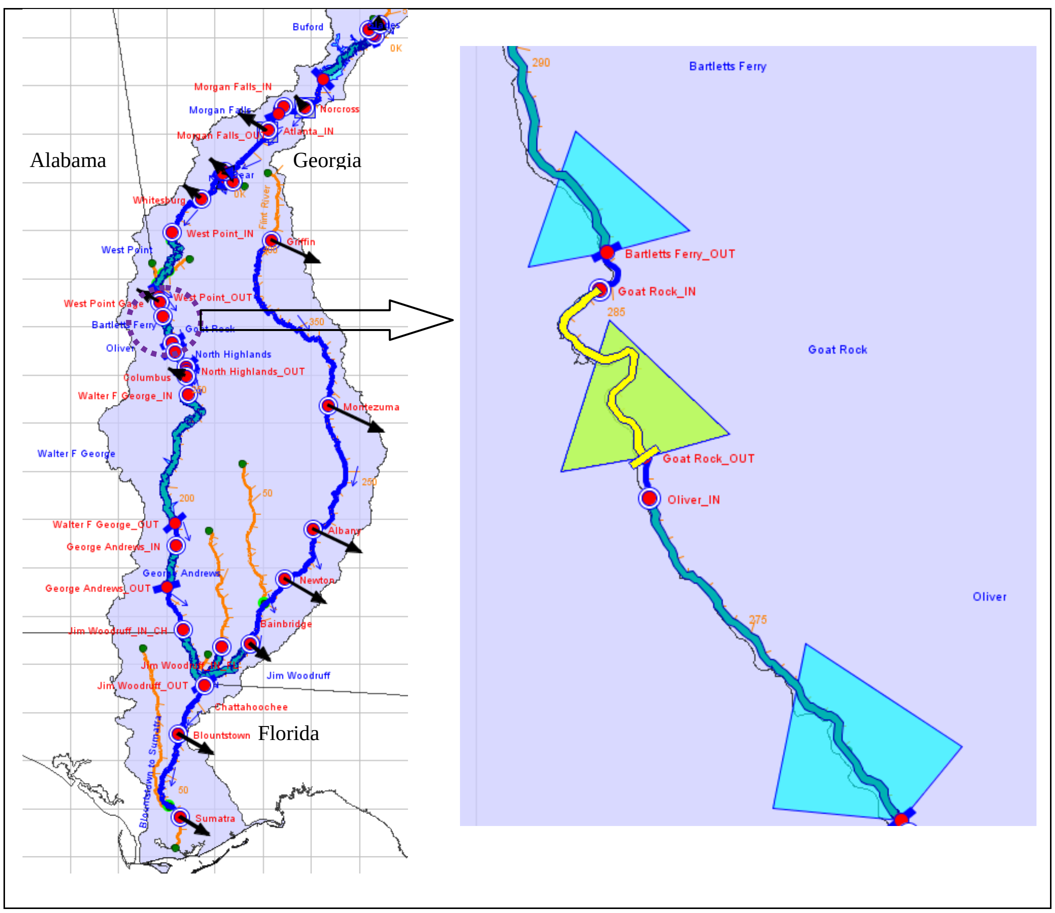


Figure F.15 HEC-ResSim Map Display Showing Location of Goat Rock

Figure F.18 shows a photo of Goat Rock Dam.

Figure F.16 Photo of Goat Rock 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 Goat Rock Reservoir in Figure F.17. Goat Rock Dam consists of three types of outlets: (1) a controlled outlet indicating the existence of a Flashboard Spillway; (2) a controlled outlet for allowing flow-thru operations; 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 F.18.

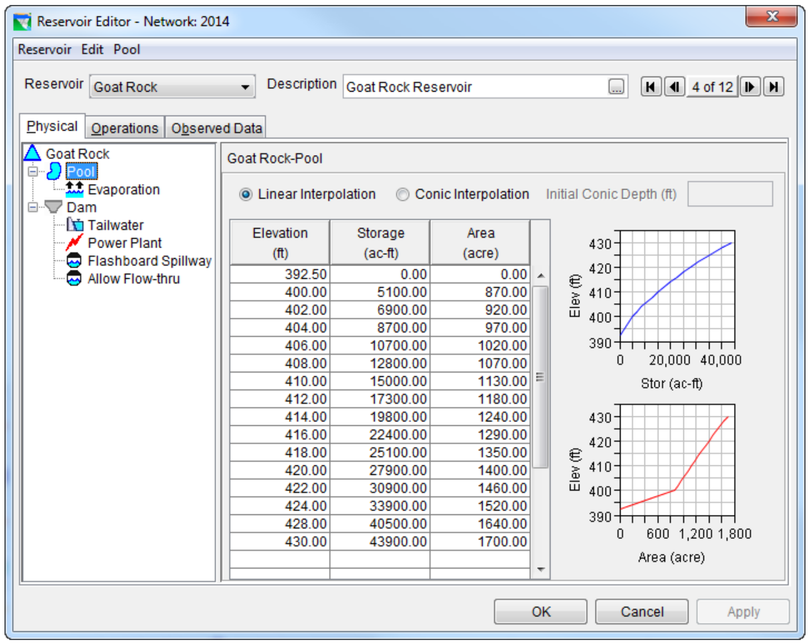


Figure F.17 Goat Rock Reservoir Editor – Network 2014: Physical Tab – Pool

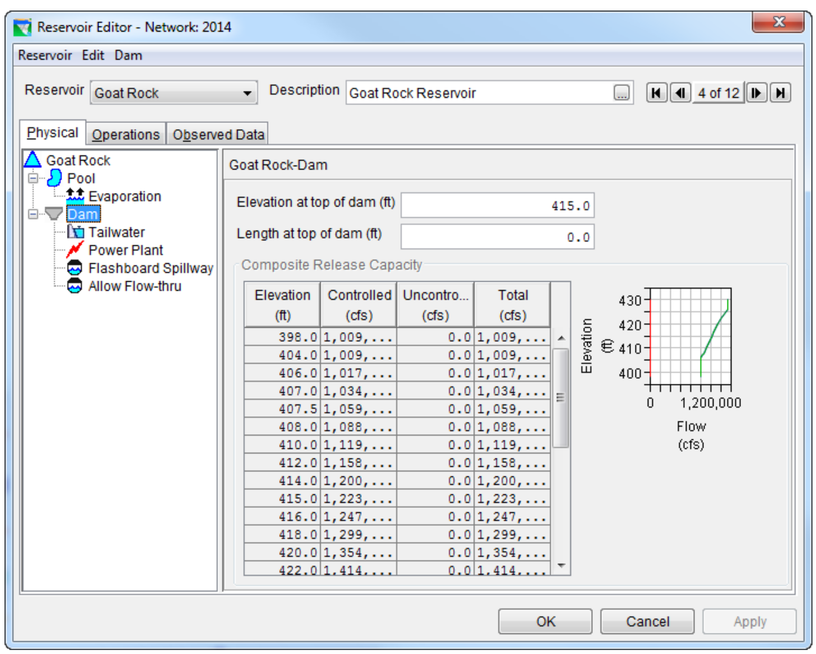


Figure F.18 Goat Rock Reservoir Editor – Network 2014: Physical Tab – Dam

C. NOAction Operations

1. *Flow-thru* Operation Set

Table F.03 shows the definition of operational zones consisting of Top of Dam and Conservation zone, as well as an Inactive zone.

Table F.03 Goat Rock Zone Elevations for *Flow-thru* Operation Set

Goat Rock	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Top of Dam	415
Conservation	404
Inactive	398

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

Figure F.20 shows a sequential release allocation approach specified for available outlets along Goat Rock 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 flashboard spillway until it reaches release capacity, at which time the release goes through the allow flow-thru outlet.

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

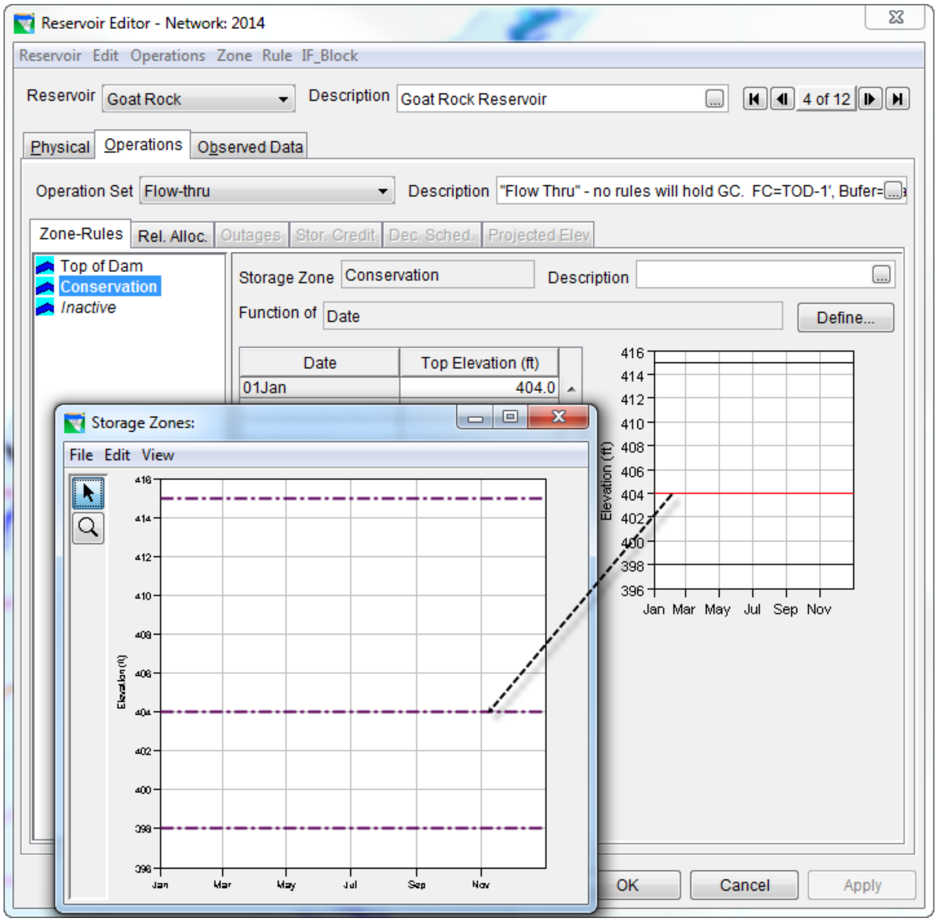


Figure F.19 Goat Rock Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Guide Curve

Release Allocation:

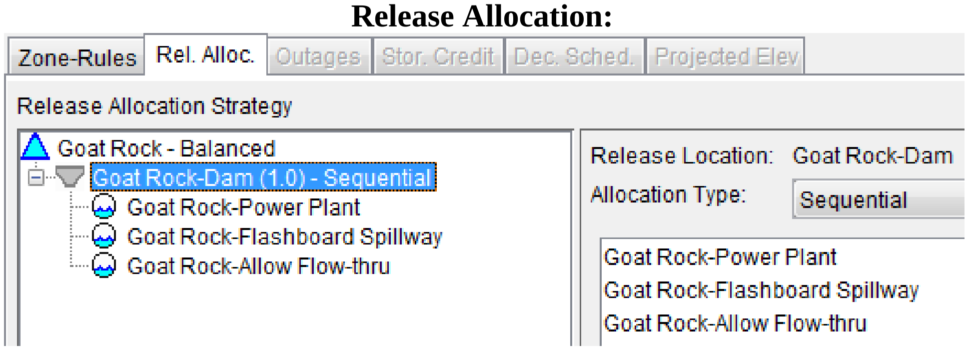


Figure F.20 Goat Rock Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Release Allocation

Figure F.21 shows a set of operational zones that reflects the operation set named *Flow-thru*. The *Flow-thru* operation set 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.

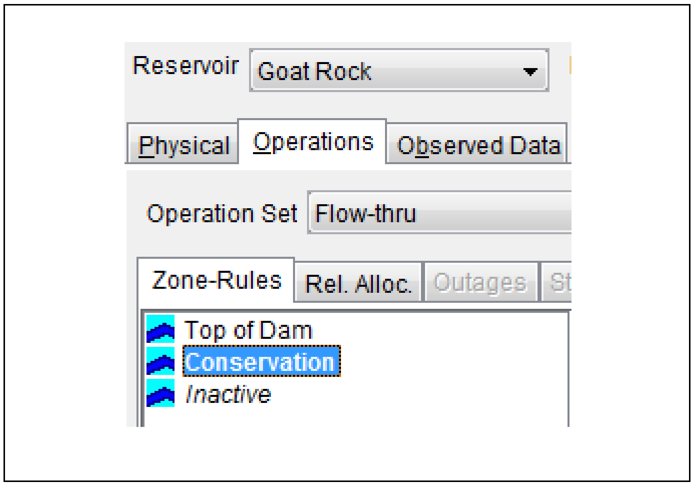


Figure F.21 Goat Rock Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Zones

D. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for Goat Rock is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

IV. Oliver

A. Overview

Oliver Dam is owned by GPC. It is located at river mile 163.5 on the Chattahoochee River and lies within Muscogee County, Georgia and Lee County, Alabama. Oliver Dam was built in 1959 and is one of the most modern hydropower facilities in the state of Georgia. It was the first completely remote controlled hydropower facility in the state of Georgia. The main purpose of the project is generation of hydro-electric power. Thus, the reservoir has very little storage capacity. Other purposes include municipal water supply, recreation, and fish and wildlife. It is operated as a run-of- river project and therefore contains little to no storage.

The Oliver hydropower facility features four generating units that have a combined capacity of 60,000 kilowatts (three 18,000 kilowatt and one 6,000 kilowatt). The combined electric output of the system can reach 240 million kilowatt hours of electricity annually. The concrete dam is 70 feet high and spans 2,021 feet across the river. The lake is roughly eight and a half miles long and features 40 miles of shoreline. The water surface elevation of the lake is approximately 337 ft above sea level and it covers about 2,150 acres of land.

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

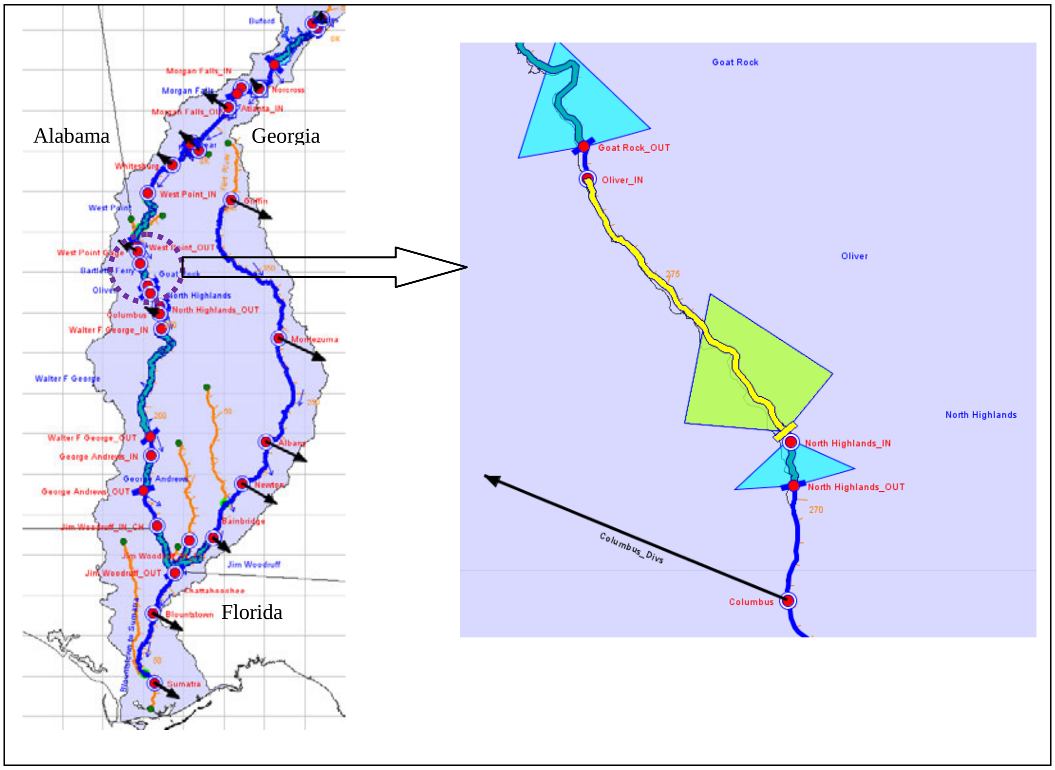


Figure F.22 HEC-ResSim Map Display Showing Location of Oliver

Figure F.23 shows a photo of Oliver Dam.

Figure F.23 Photo of Oliver 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 Oliver Reservoir in Figure F.24. Oliver 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 all of the outlets as shown in Figure F.25.

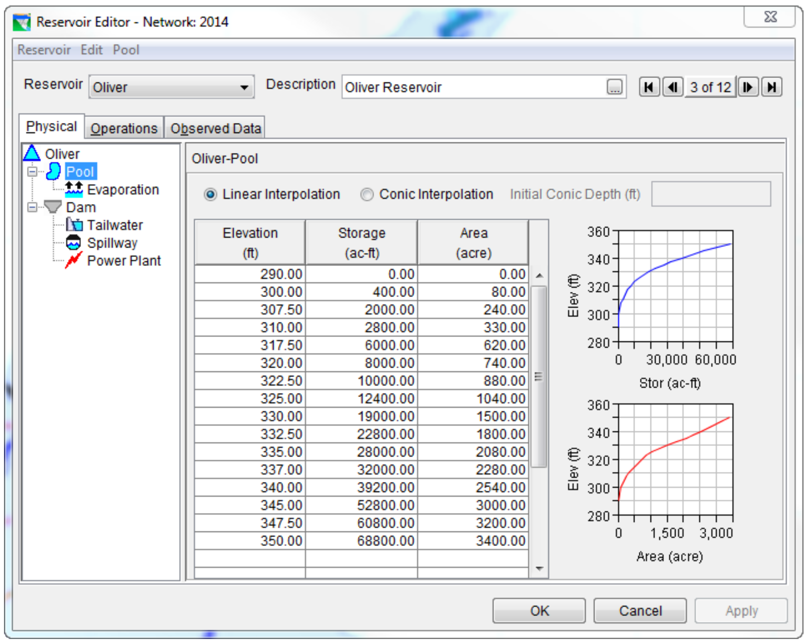


Figure F.24 Oliver Reservoir Editor – Network 2014: Physical Tab – Pool

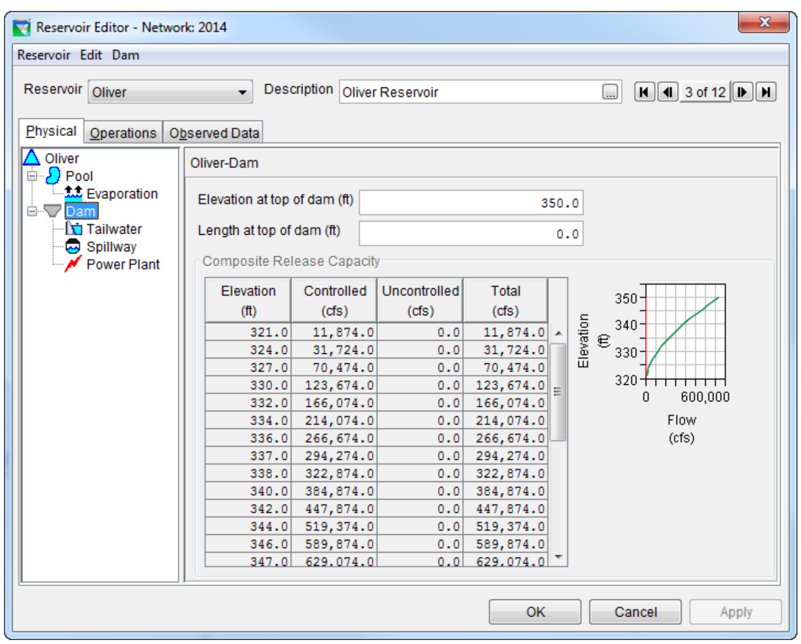


Figure F.25 Oliver Reservoir Editor – Network 2014: Physical Tab – Dam

C. NOAction Operations

1. *Flow-thru* Operation Set

Table F.04 shows the definition of operational zones consisting of Top of Dam and Conservation zone, as well as an Inactive zone.

Table F.04 Oliver Zone Elevations for *Flow-thru* Operation Set

Oliver	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Top of Dam	350
Conservation	337
Inactive	334

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

Figure F.27 shows a sequential release allocation approach specified for available outlets along Oliver 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.

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

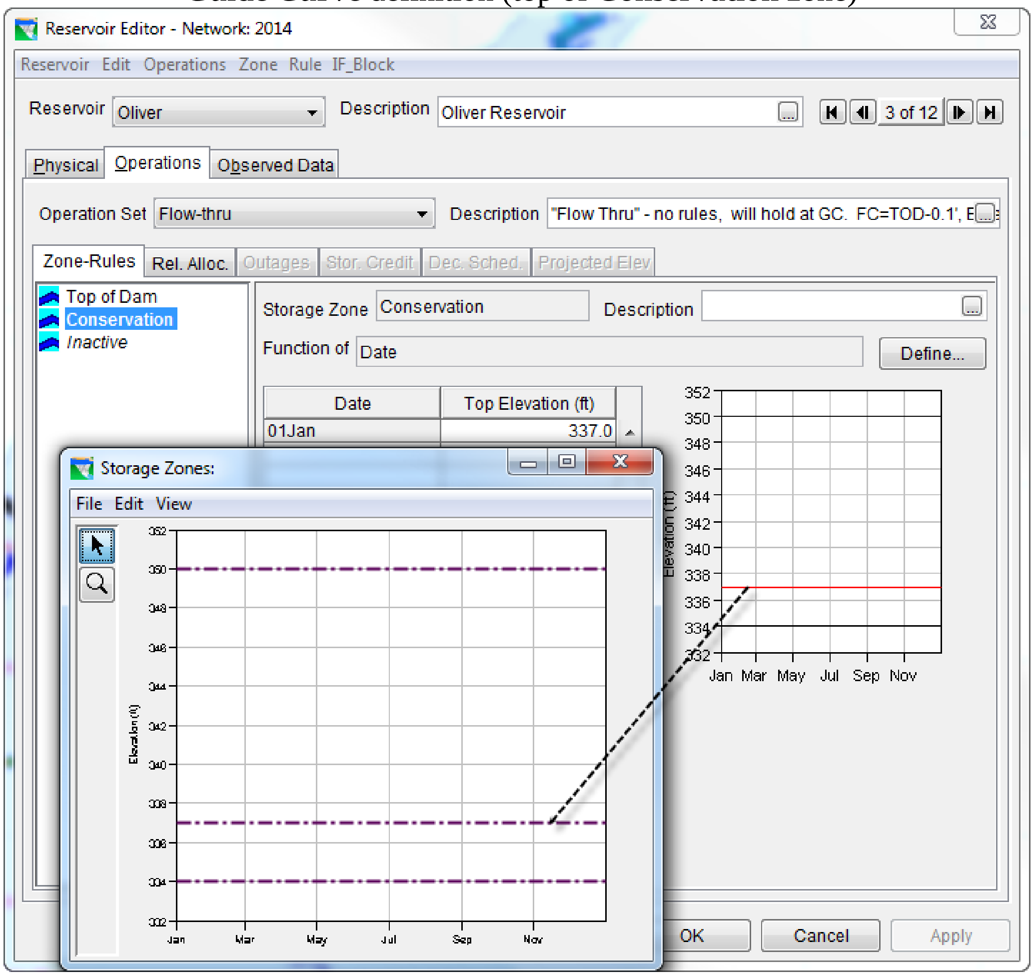


Figure F.26 Oliver Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Guide Curve

Release Allocation:

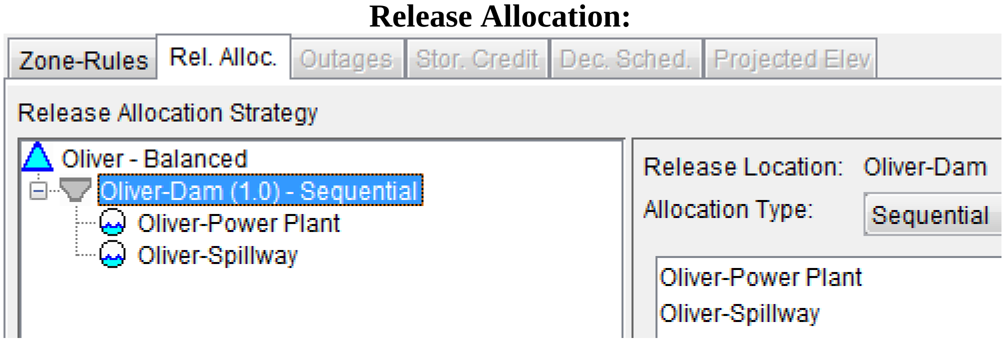


Figure F.27 Oliver Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Release Allocation

Figure F.28 shows a set of operational zones that reflects the operation set named *Flow-thru*. The *Flow-thru* operation set 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.

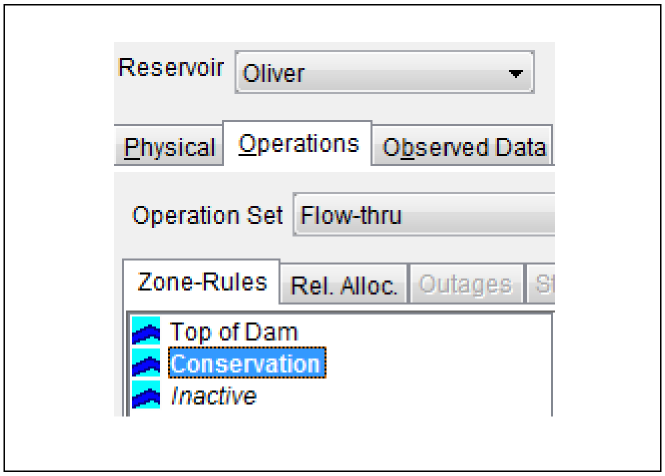


Figure F.28 Oliver Reservoir Editor – Network 2014: Operations Tab –*Flow-thru* Zones

D. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for Oliver is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

V. North Highlands

A. Overview

North Highlands Dam is owned by GPC. It is located on the Chattahoochee River between Oliver Dam and City Mills Dam in Columbus, Georgia. The dam was completed in 1903 and stands 33 feet high. As a relatively small reservoir with 3 miles of shoreline, it operates in a run-of-river mode by GPC. The name plate capacity is 29.6 MW with 4 power generating units. The dam was originally built for power generation and has very little flood storage capacity. The total drainage area upstream of North Highlands Dam is 4,670 square miles.

Figure F.29 shows the location of North Highlands Reservoir as it is represented in the HEC-ResSim model.

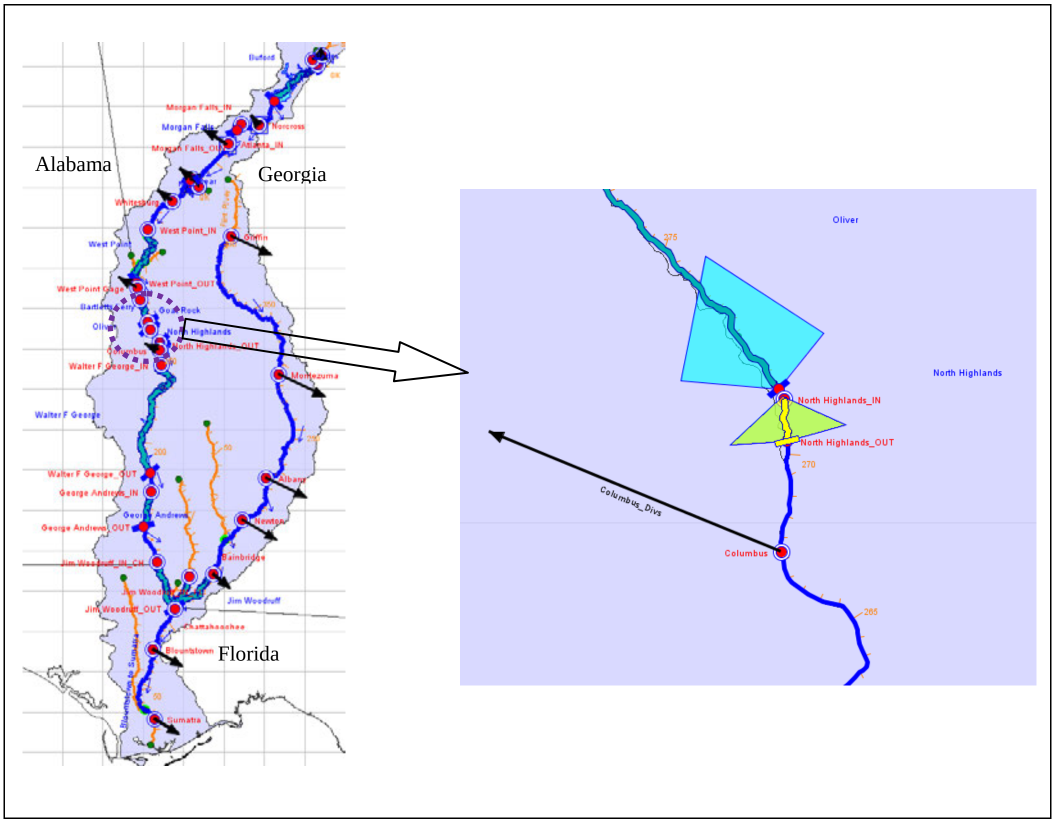


Figure F.29 HEC-ResSim Map Display Showing Location of North Highlands

Figure F.30 shows a photo of North Highlands Dam.

Figure F.29 Photo of North Highlands 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 North Highlands Reservoir in Figure F.33. North Highlands Dam consists of three types of outlets: (1) a controlled outlet indicating the existence of a Flashboard Spillway; (2) a controlled outlet for allowing flow-thru operations; 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 F.34.

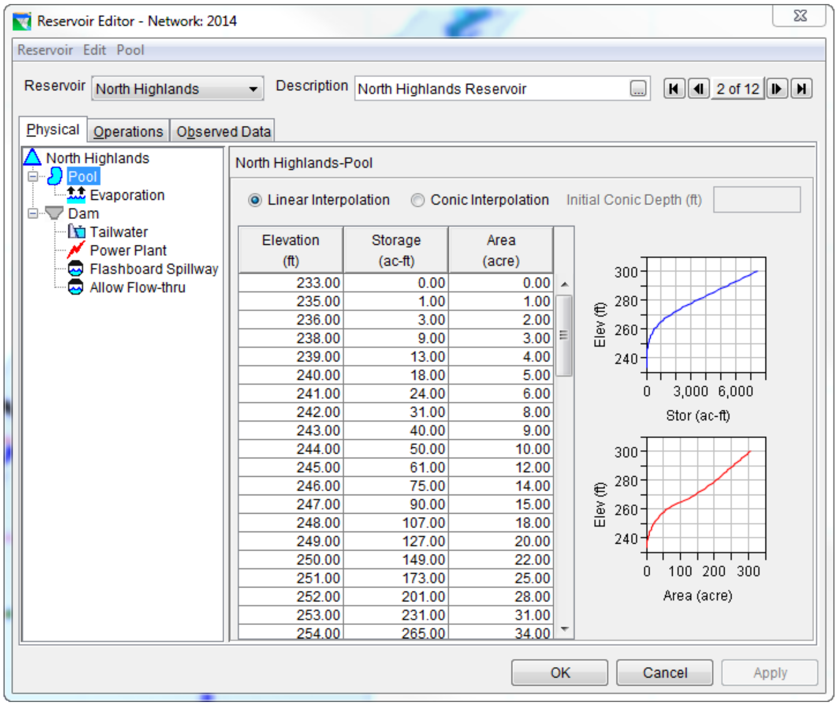


Figure F.30 North Highlands Reservoir Editor – Network 2014: Physical Tab – Pool

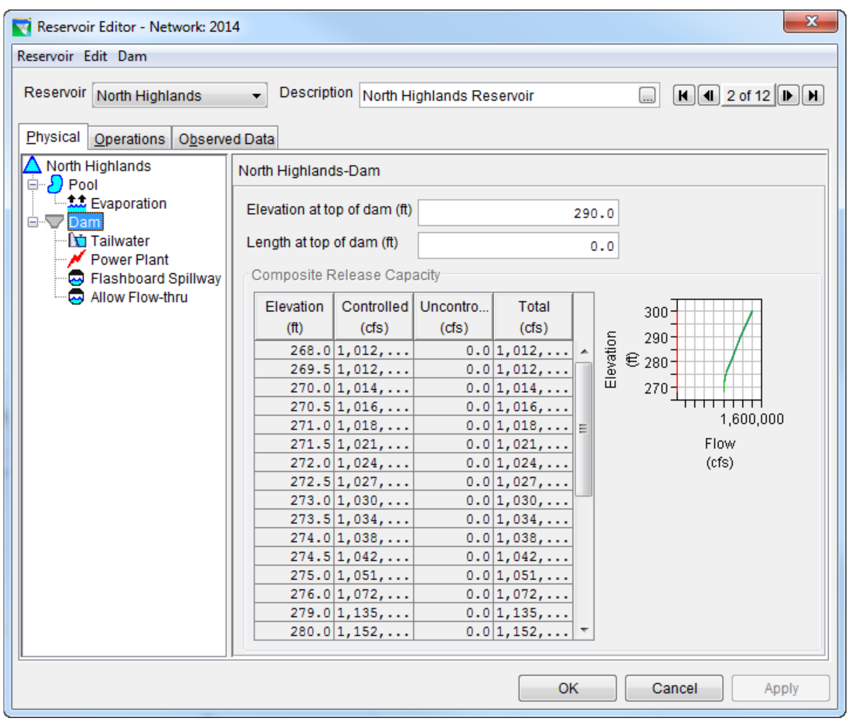


Figure F.31 North Highlands Reservoir Editor – Network 2014: Physical Tab – Dam

C. NOAction Operations

1. *Flow-thru* Operation Set

Table F.05 shows the definition of operational zones consisting of Top of Dam and Conservation zone, as well as an Inactive zone.

Table F.05 North Highlands Zone Elevations for *Flow-thru* Operation Set

North Highlands	Flow-thru Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Top of Dam	290
Conservation	269
Inactive	268

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

Figure F.34 shows a sequential release allocation approach specified for available outlets along North Highlands 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 flashboard spillway until it reaches release capacity, at which time the release goes through the allow flow-thru outlet.

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

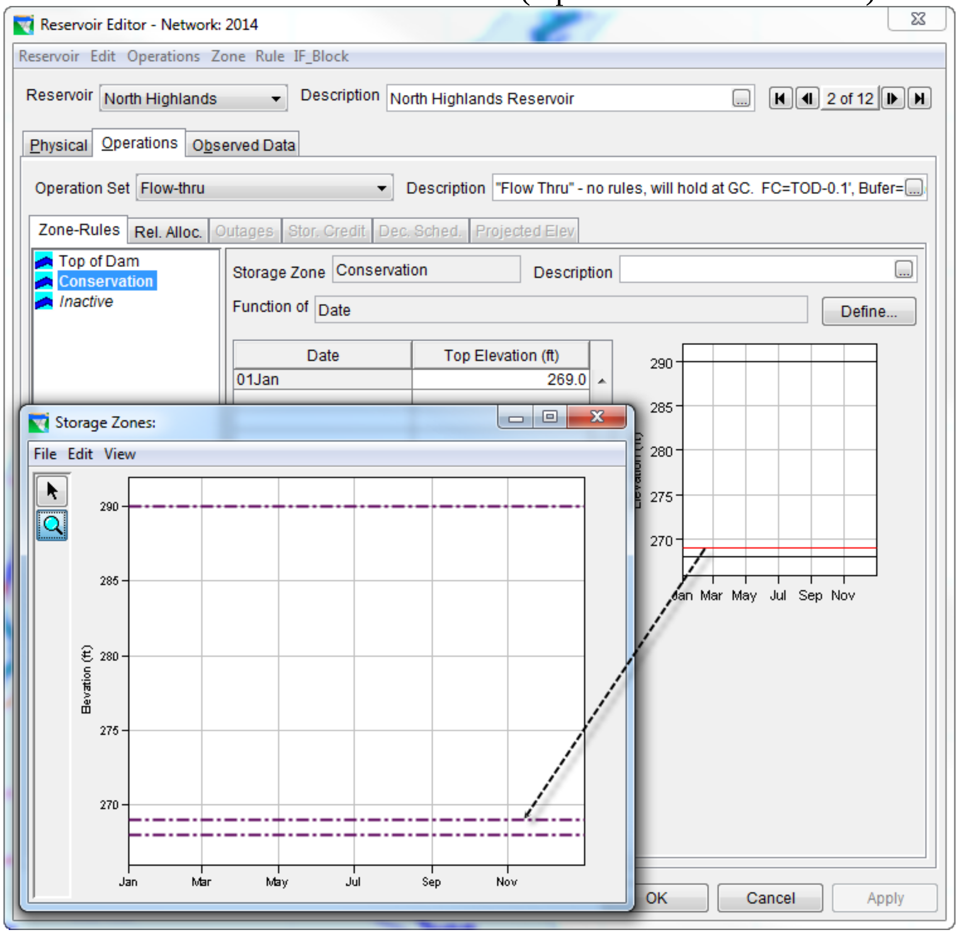


Figure F.32 North Highlands Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Guide Curve

Release Allocation:

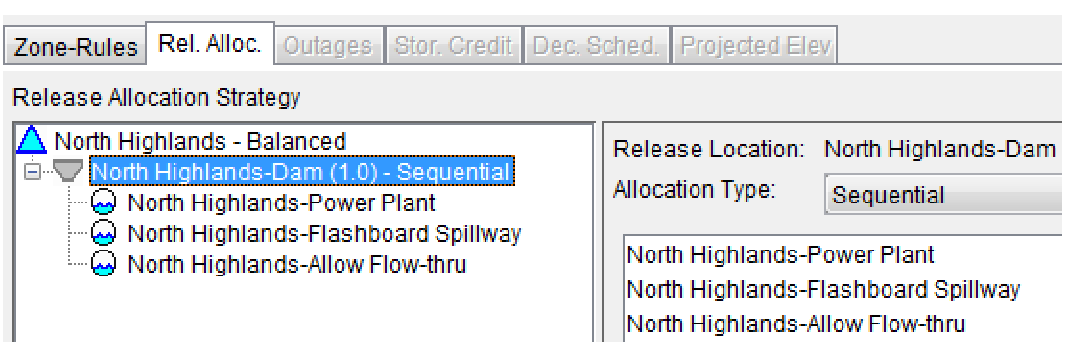


Figure F.33 North Highlands Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Release Allocation

Figure F.35 shows a set of operational zones that reflects the operation set named *Flow-thru*. The *Flow-thru* operation set 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.

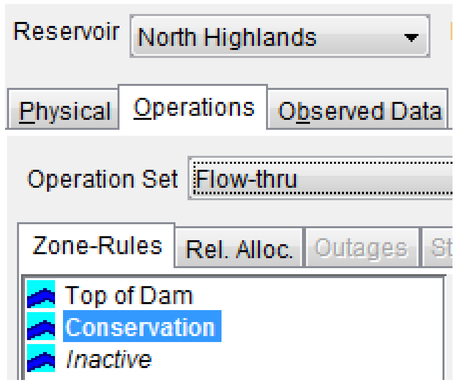


Figure F.34 North Highlands Reservoir Editor – Network 2014:Operations Tab – *Flow-thru* Zones

D. Alternative Operations – *Same as NOAction*

The *Flow-thru* operation set for North Highlands is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix G – Proposed Reservoirs:

Glades, Bear Creek

June 2014

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Table of Contents:

List of Tables:

List of Figures:

"Proposed" Reservoirs

I. Glades

A. Overview

Hall County proposes to construct a dam on Flat Creek, a tributary of the Chattahoochee River, to create the Glades Reservoir. The primary purpose of the proposed reservoir is for long-term water supply for Hall County, Georgia. The Applicant proposes to construct an earthen embankment dam with a height of approximately 115 feet and a crest length of 1,000 feet. The top of dam elevation is estimated to be at 1,195 feet above mean sea level (ft MSL) and the normal pool water surface elevation is proposed to be at 1,180 ft MSL. The Applicant estimated that 20% of the total storage will be reserved for sediment storage.

The outlet works consists of a controlled outlet for release to Flat Creek below the dam and a spillway. The proposed dam is designed to pass the annual 7-day, 10-year minimum flow (7Q10) of Flat Creek, estimated at 4.6 cubic feet per second (cfs) or the natural inflow, whichever is less. When the proposed Glades Reservoir reaches capacity at the normal pool water surface elevation of 1,180 ft MSL, all additional volume is passed through the spillway. The spillway length and weir coefficients were estimated by the Applicant. The spillway has not been designed (but is assumed to be an efficient ogee weir structure). The estimated value for the weir coefficient is 3.8 and for weir length is 300 ft.

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

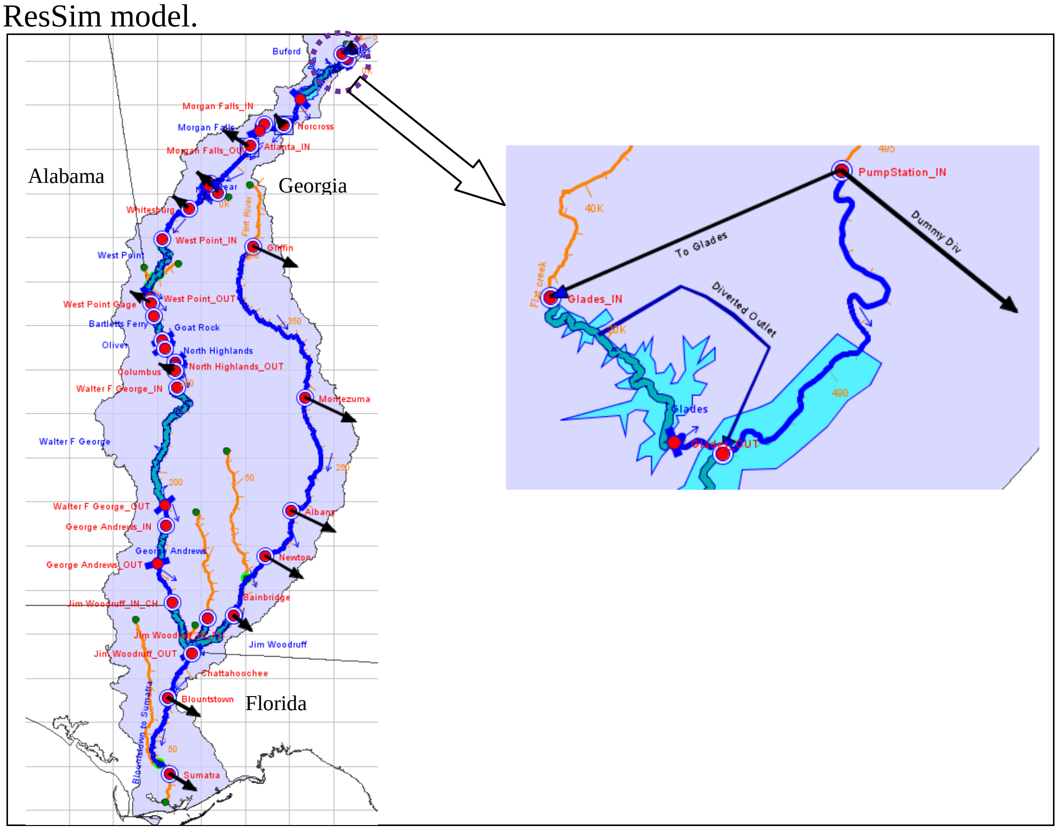

Figure G.01 HEC-ResSim Map Display Showing Location of Glades

B. Physical Characteristics

The physical characteristics of a reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” table defines the pool as shown for Glades Reservoir in Figure G.02. Evaporation losses are specified on the pool; the evaporation rate is provided as an input time series. Glades Dam was given two outlets: (1) a controlled outlet-to Flat Creek to release the minimum flow and (2) an uncontrolled spillway. A third outlet was assigned to the reservoir, a diverted outlet, to represent the water supply withdrawal. The diverted outlet currently releases water directly to Buford_IN. The capacity of the diversion has not been specified by the application so a value representing the maximum 1 day withdrawal rate requested by the applicant was used. The composite release capacity of the outlets releasing into Flat Creek is shown in Figure G.03.

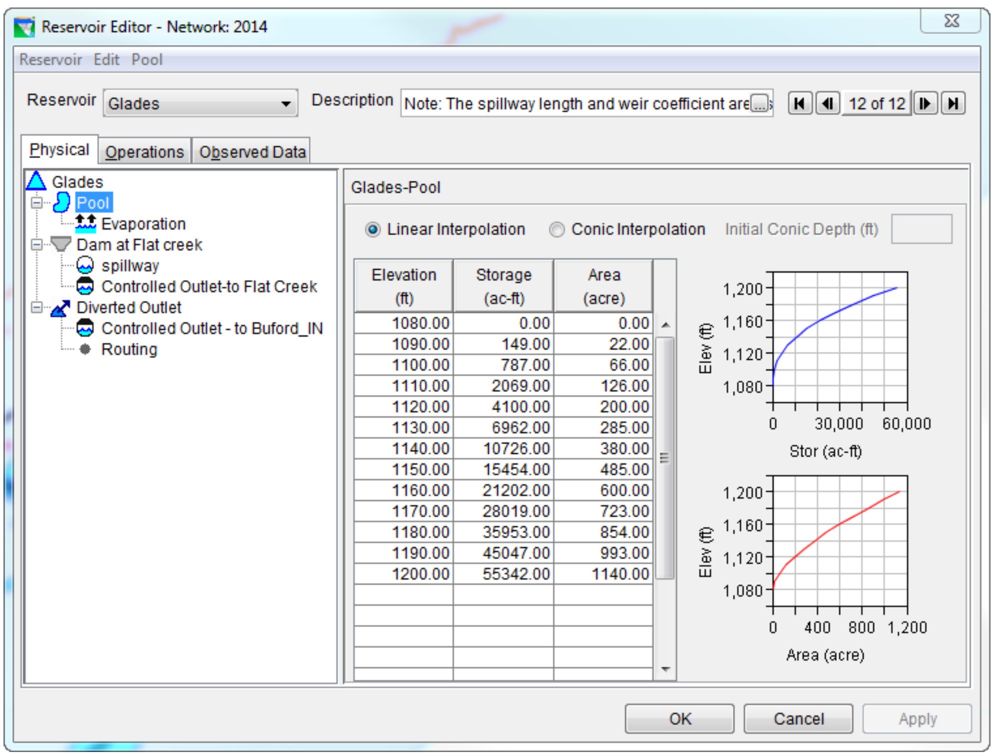

Figure G.02 Glades Reservoir Editor – Network 2014: Physical Tab – Pool

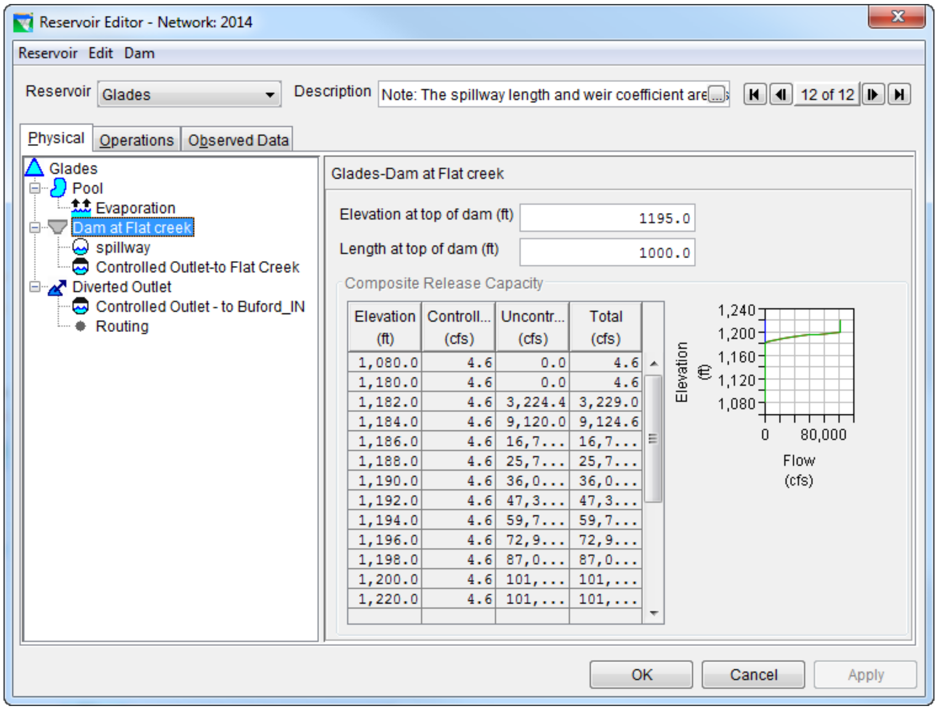

Figure G.03 Glades Reservoir Editor – Network 2014: Physical Tab – Dam

C. Operation Sets

1. NO-Action Operation Set

The expected operations of Glades reservoir were not fully defined by the applicant so the NO-Action model is representing the reservoir as an “amenity lake”. As such, the reservoir must meet the required releases to Flat Creek and may pump from the Chattahoochee only enough water to maintain a normal pool level. No water supply diversion is defined for this operation set.

Table G.01 shows the definition of the operational zones specified for Glades Reservoir. They include Flood Control, Conservation, and Inactive zone. The Inactive zone reflects the expected sediment storage and the Conservation Zone is the expected water supply storage. Since Glades is not expected to operate for Flood Control, the Flood Control zone effectively represents the storage above “full”.

Table G.01 Glades Zone Elevations for “NO-Action” Operation Set

Glades	NO-Action Top of Zone Elevation Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Flood Control	1195
Conservation	1180
Inactive	1130.5

The curves describing the top of each zone are assumed to be constant throughout the entire year (as shown in Figure G.04).

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

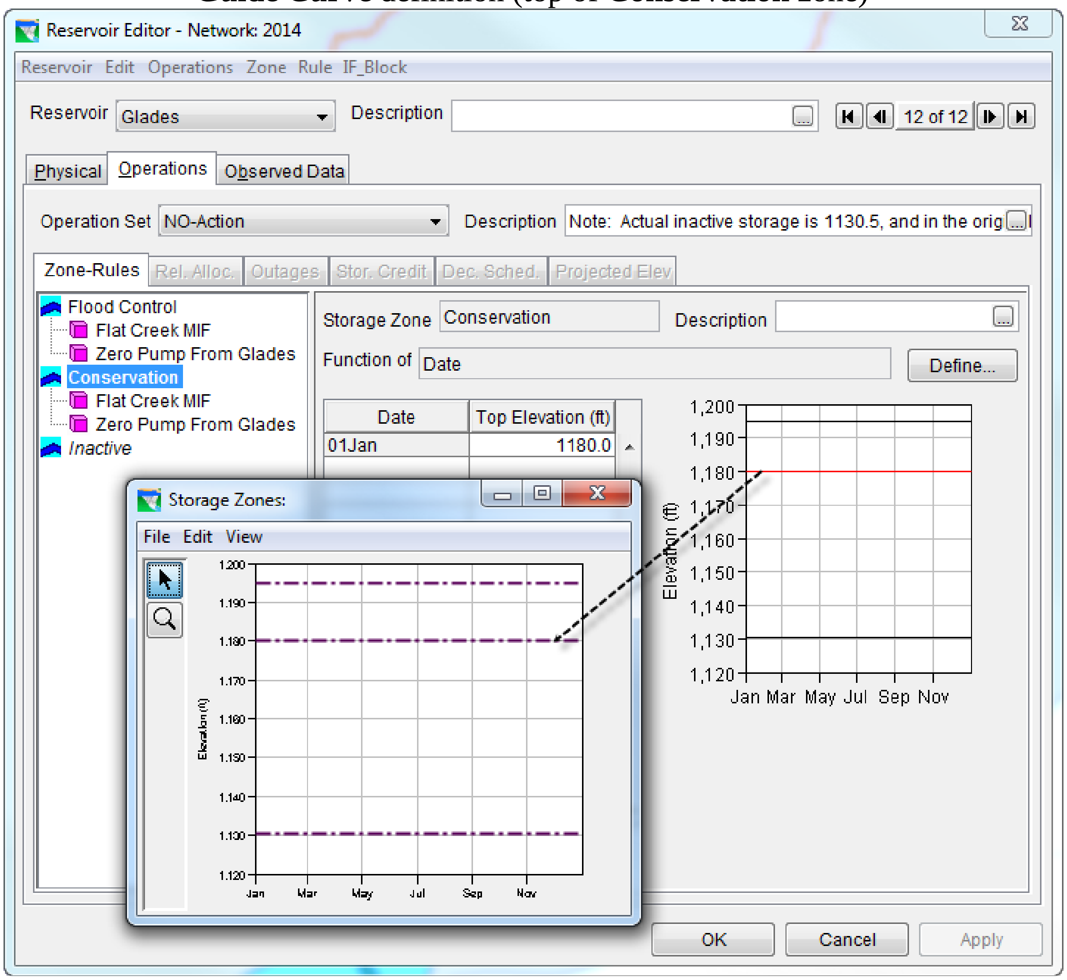

Figure G.04 Glades Reservoir Editor – Operations Tab – "NO-Action" Guide Curve

2. Water Supply Operation Set

Water Supply operation set is a copy of NO-Action operation set except that it has a rule specified for water supply withdrawal. Figure G.05 shows the top of each zone for water supply operation set.

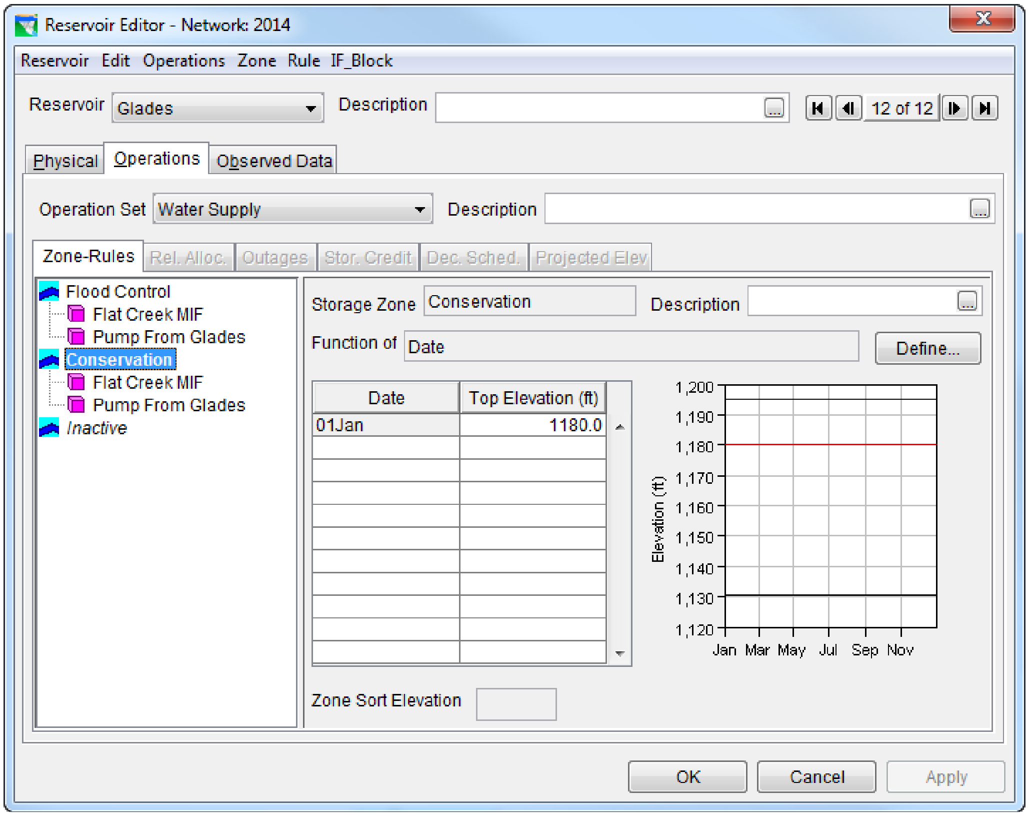

Figure G.05 Glades Reservoir Editor – Operations Tab – "Water Supply" Guide Curve

3. Rule Illustration

Figure G.06 and Figure G.07 show a set of operational rules specified for each zone that reflects the operation set named "NO-Action" and "Water Supply" respectively.

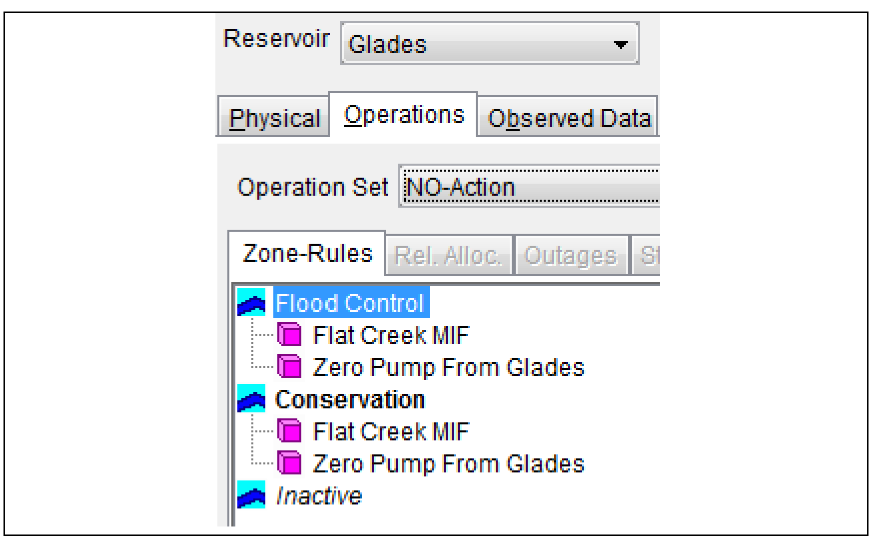

Figure G.06 Glades Reservoir – "NO-Action" Operation Set, Zones

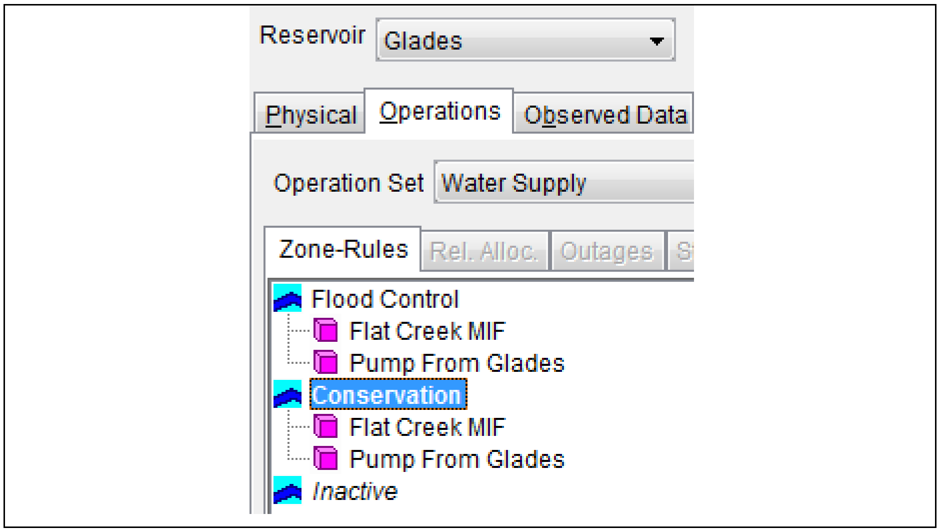

Figure G.07 Glades Reservoir – "Water Supply" Operation Set, Zones

The content for each of the rules specified for Glades Reservoir in the ResSim model are shown in Figure G.08 through Figure G.10. The logic and purpose for each operational rule is described in Section 4.

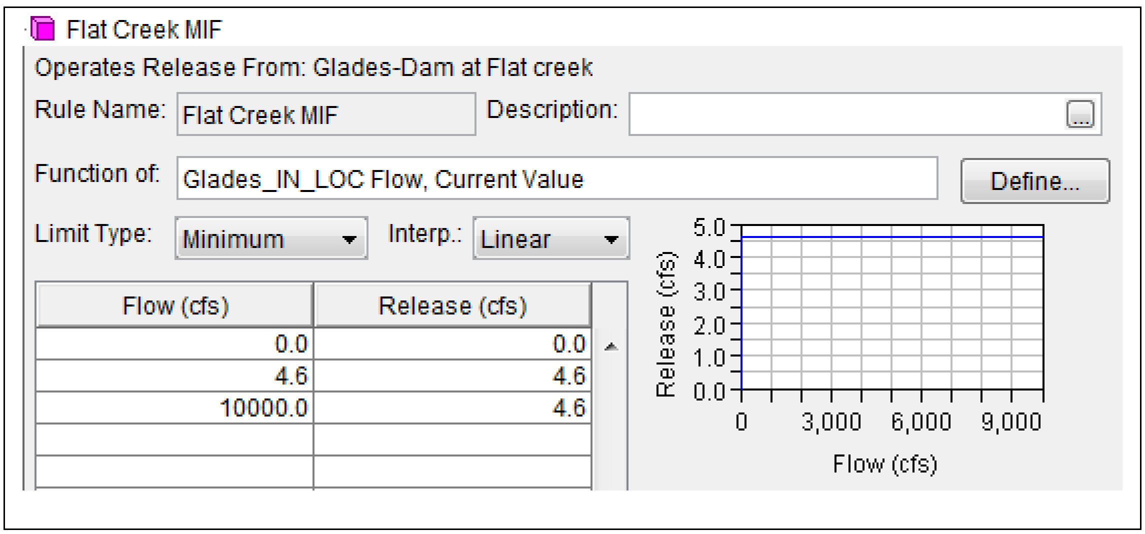

Figure G.08 Glades Reservoir – Flat Creek MIF rule

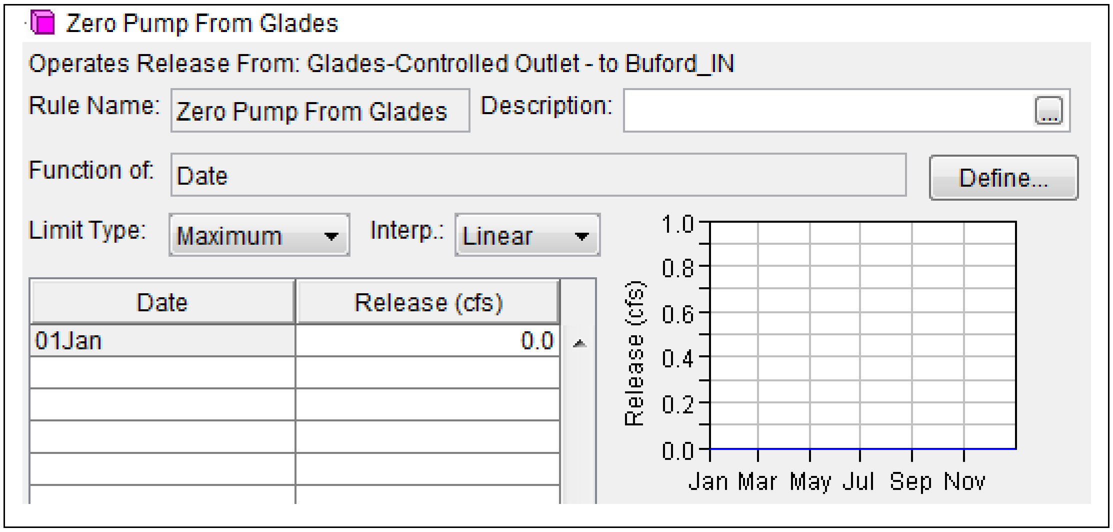

Figure G.09 Glades Reservoir – Zero Pump From Glades rule

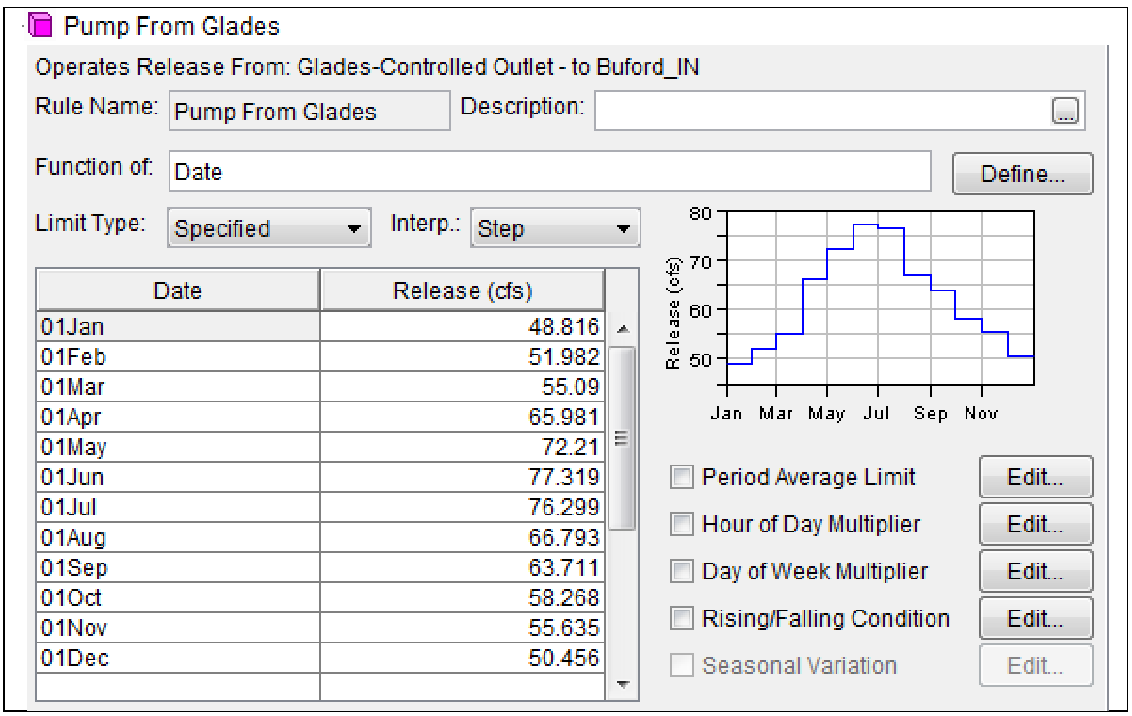

Figure G.10 Glades Reservoir –Pump From Glades rule

4. Rule Description

4.1 - Flat Creek MIF

This rule (see Figure G.08) represents the flow release from the dam. The proposed dam is designed to pass the annual 7-day, 10-year minimum flow (7Q10) of Flat Creek, estimated at 4.6 cubic feet per second (cfs) or the natural inflow, whichever is less.

4.2 – Zero Pump From Glades

This rule (see Figure G.09) represents a zero water supply withdrawal from Glades.

4.3 –Pump From Glades

This rule (see Figure G.10) represents the water supply diversion from Glades to Buford_IN. An annual average of 40 mgd is withdrawn from Glades in water supply operation set.

5. Pump from Chattahoochee River to Glades Reservoir

The Chattahoochee River Pump Station will pump to Glades Reservoir when flow in the River just upstream of the pump station exceeds the annual 7Q10 (183.5 cfs), and when water level in Glades Reservoir is lower than 1,180 ft MSL. When the flow rate in the Chattahoochee River is less than or equal to the annual 7Q10, the pump station will not operate, even if Glades Reservoir's water level is lower than 1,180 ft MSL. The state variable that determines how much to pump to Glades pool each time step is called "PumpToGlades". This state variable needs to access the Glades' pool elevation at each time step. In order to have the "PumpStation_IN" junction and Glades reservoir in the same compute block to that the pool elevation is accessible to the state variable script, a diversion named "Dummy Div" was added to the "PumpStation_IN" junction and specified to be function of Glades_Pool Elevation. The diversion function is zero for all values of pool elevation so that the "Dummy Div" diverts no water from the system.

Figure G.11 illustrates how the "ToGlades" diversion was defined. Note that the diversion is a function of the state variable "PumpToGlades" and the function in the table is a one-to-one relationship up to 60.3 cfs, the pump capacity specified by the applicant.

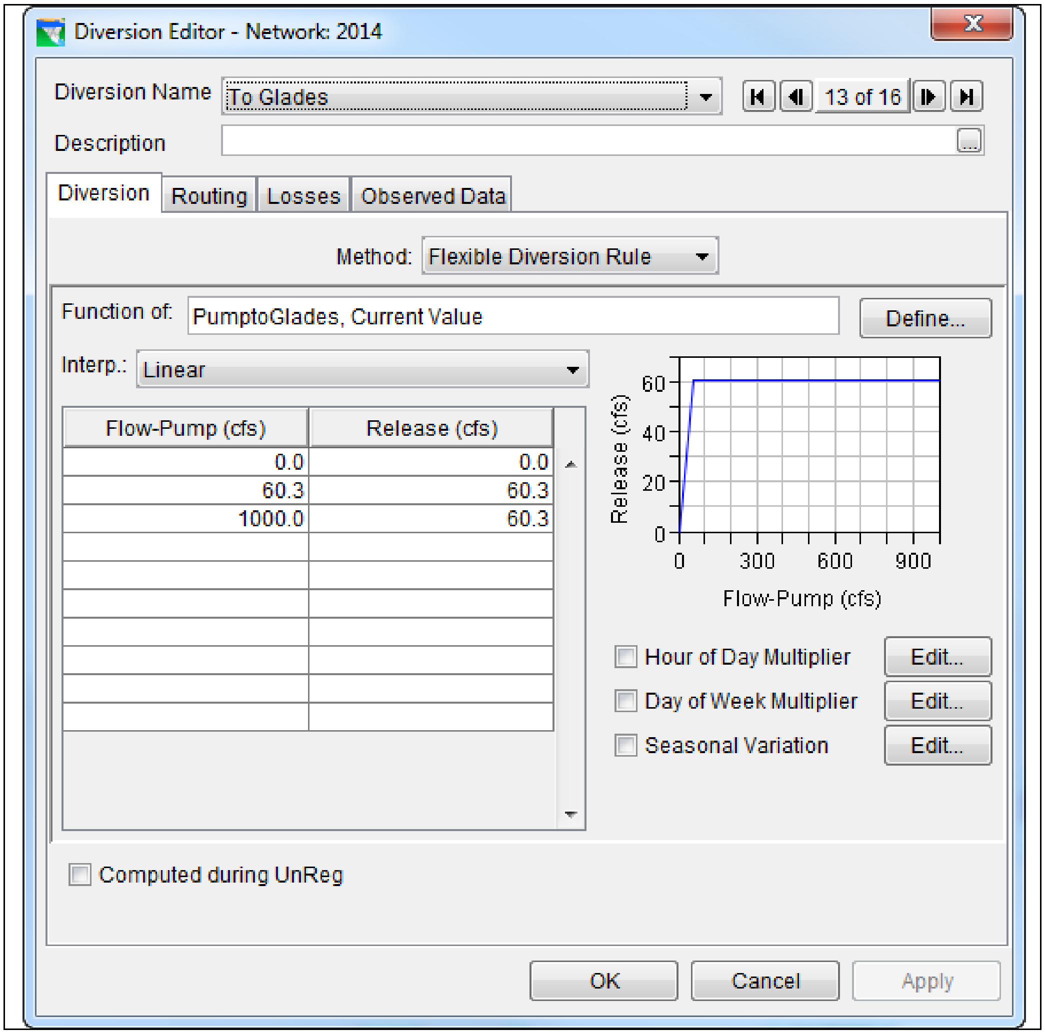

Figure G.11 Diversion Editor – Network 2014: To Glades

D. Alternative Operations

The Glades operation set for Glades reservoir is the same for all alternatives and is the same operation set that was used for the NOAction alternative except the ones that use water supply option H which is defined in section X of Appendix K. (Figure N.90). For the alternatives that are combined with water supply option H "Water Supply" operation set should be used.

II. Bear

A. Overview

The South Fulton Municipal Regional Water and Sewer Authority (Authority) was authorized during the 2000 session of the Georgia General Assembly to establish a regional approach to provide for the existing and future water supply needs of the cities of Fairborn, Palmetto and Union City located in the southern portion of Fulton County. In an effort to provide for the future water supply needs, the Authority began evaluating locations for a raw water supply reservoir. Upon completion of the evaluations, a dam site located on Bear Creek approximately 2400 ft upstream of the confluence with Chattahoochee River was selected to impound a 440 acre reservoir capable of meeting the future needs of the community.

The Bear Creek Reservoir project is proposed for development in two phases. In the initial phase, the minimum releases from the reservoir will be met entirely from the Bear Creek reservoir and its inflows. During the build-out phase, a pump station will be constructed on the Chattahoochee River that will divert flows to the reservoir. With the pump station in place, the reservoir can operate to meet a water supply demand from South Fulton communities.

Figure G.12 shows the location of Bear Creek Reservoir as it is represented in the HEC-ResSim model.

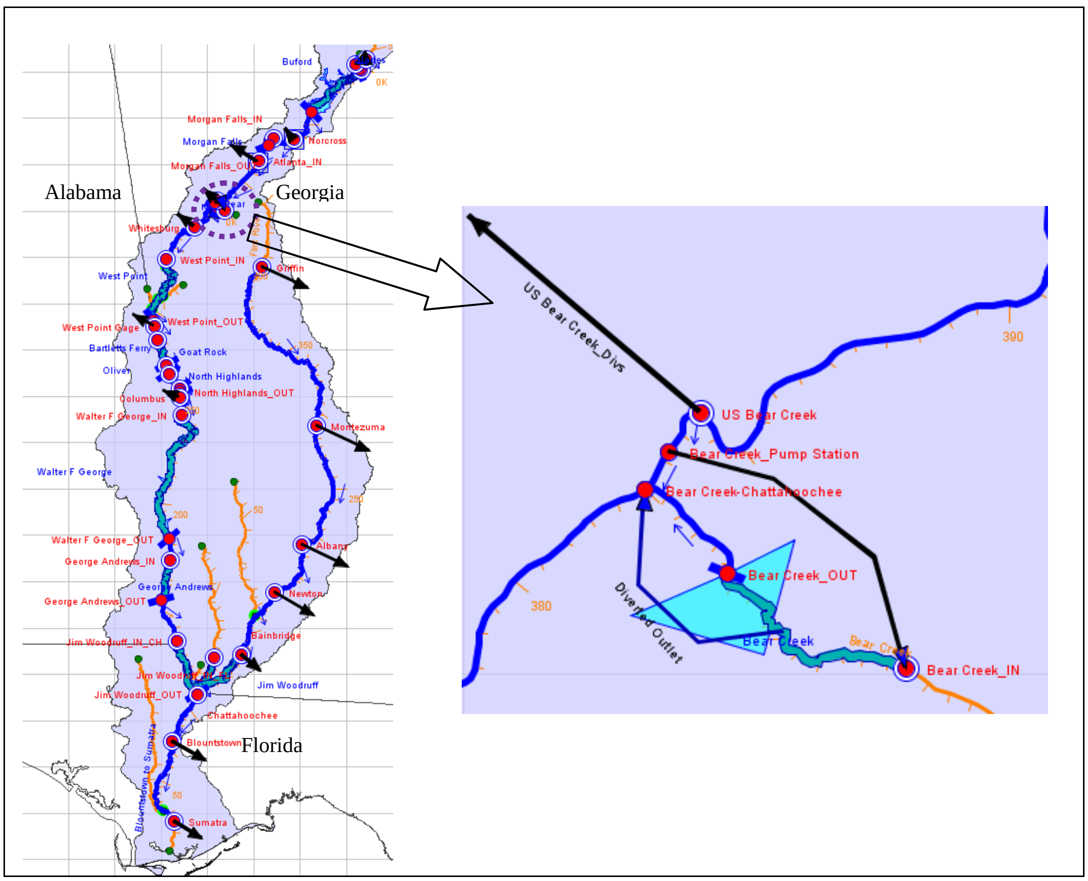

Figure G.12 HEC-ResSim Map Display Showing Location of Bear Creek Reservoir

B. Physical Characteristics

The physical characteristics of a reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” table defines the pool as shown for Bear Reservoir in Figure G.13. Evaporation losses are specified on the Bear pool and the evaporation rate is specified as an input time series. Bear Creek reservoir was modeled with three outlets: (1) a controlled outlet and (2) an overflow spillway at the dam to release water into Bear Creek and (3) a diverted outlet to represent the water supply diversion. The composite release capacity of the outlets releasing into Bear Creek is shown in Figure G.14.

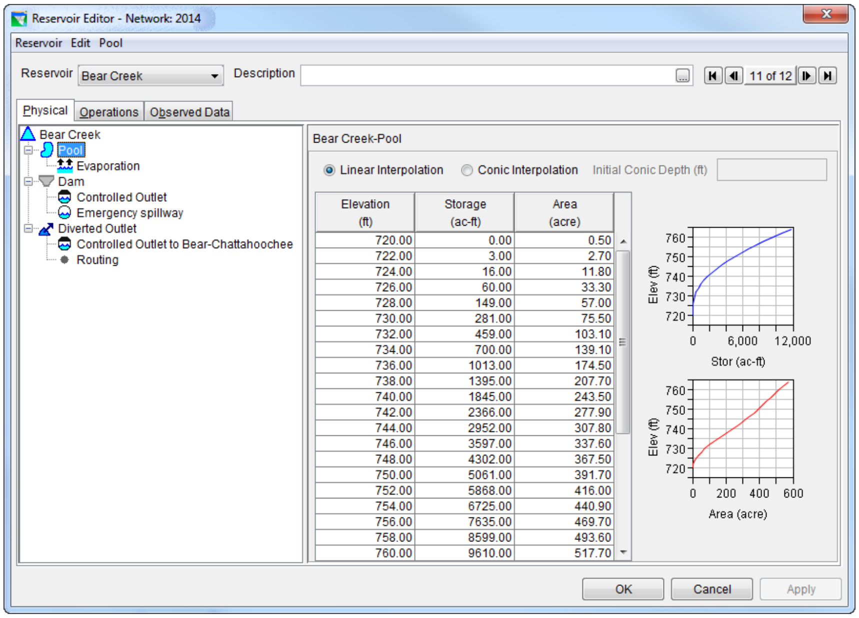

Figure G.13 Bear Creek Reservoir Editor – Network 2014: Physical Tab – Pool

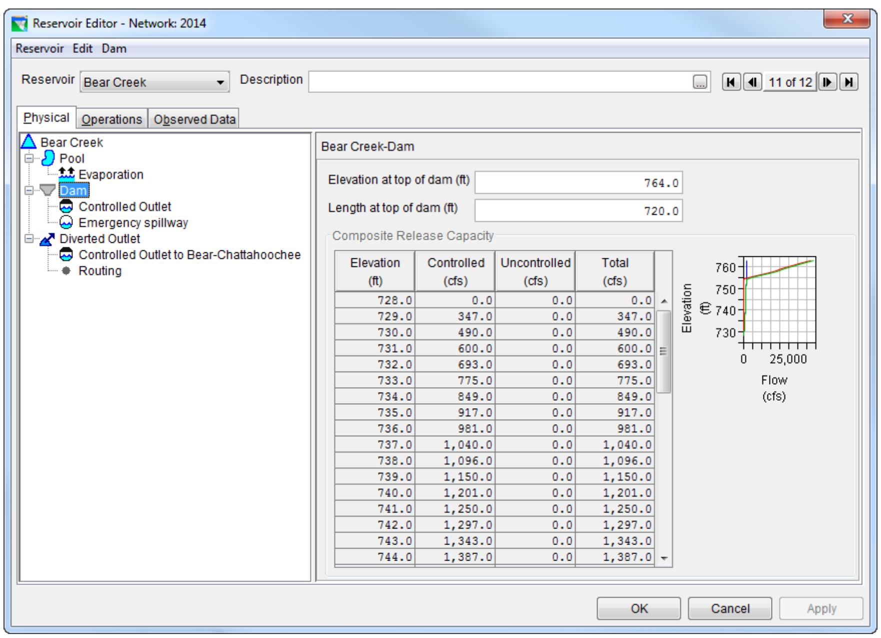

Figure G.14 Bear Creek Reservoir Editor – Network 2014: Physical Tab – Pool

C. Operation set

1. NO-Action Operation Set

The expected operations of Bear Creek Reservoir detailed in Bear Creek proposal. The lake and its inflow would be used to meet a minimum flow requirement of 3.1 cfs to Bear Creek. With the addition of pumped water from the Chattahoochee, the reservoir would also operate to meet maximum "safe yield" water supply diversion of 25.41 cfs. The pump is expected to operate only if the flow in the Chattahoochee exceeds a seasonally varying minimum requirement and the storage at Bear Creek Reservoir has fallen below 80% of "full".

Table G.02 shows the definition of the operational zones specified for Bear Creek reservoir. These zones include Flood Control, Conservation, and Inactive. Since this reservoir is not expect to operate for flood control, the Flood Control zone represent the storage above "full".

Table G.02 Bear Creek Zone Elevations for "NO-Action" Operation Set

Bear	**NO-Action** Top of **Zone Elevation** Values (feet) Blue values = entered into ResSim
Zones	**Season = 1Jan - 31Dec**
Flood Control	764
Conservation	754
Inactive	738

The curves describing the top of each zone are assumed to be constant throughout the entire year (as shown in Figure G.15).

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

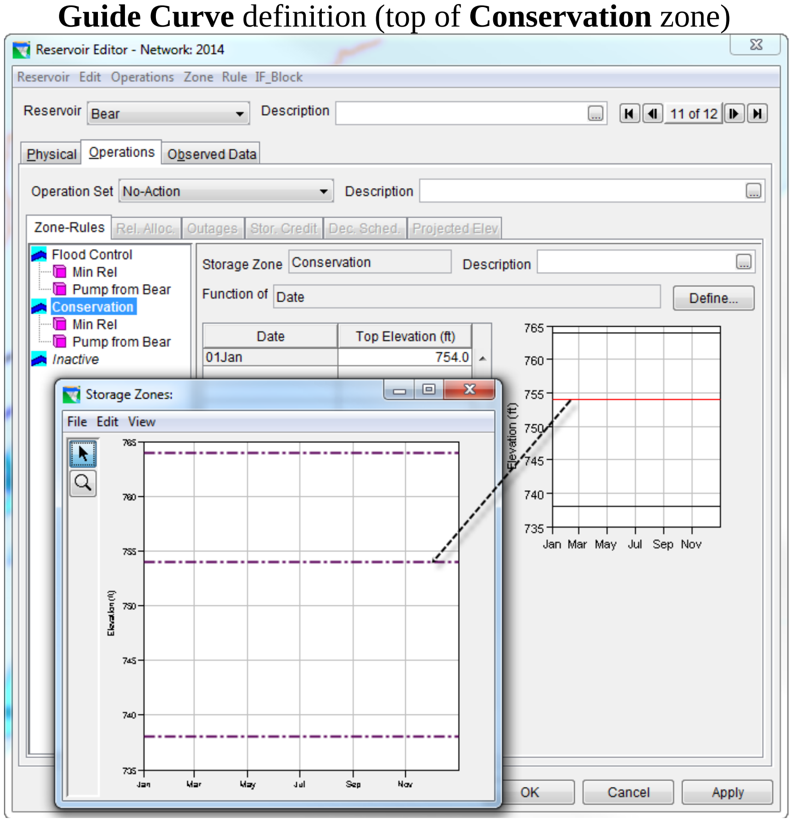

Figure G.15 Bear Reservoir Editor – Network 2014: Operations Tab –"NO-Action"Guide Curve

2. Rule Illustration

Figure G.16 shows the operation rules specified for each zone in the "NO-Action" operation set.

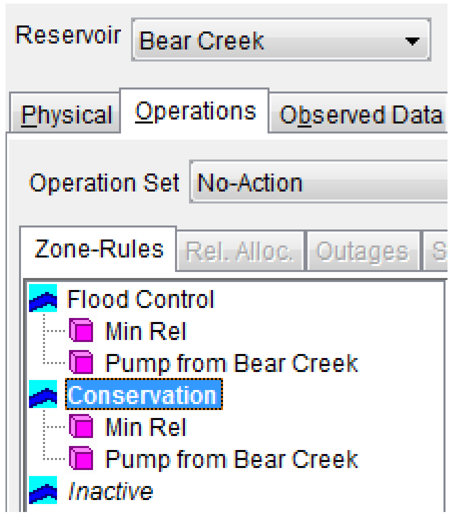

Figure G.16 Bear "NO-Action" OpSet, Zones

The definition of each of these rules is shown in Figure G.17 and Figure G.18. The logic and purpose for each operational rule is described in Section 3.

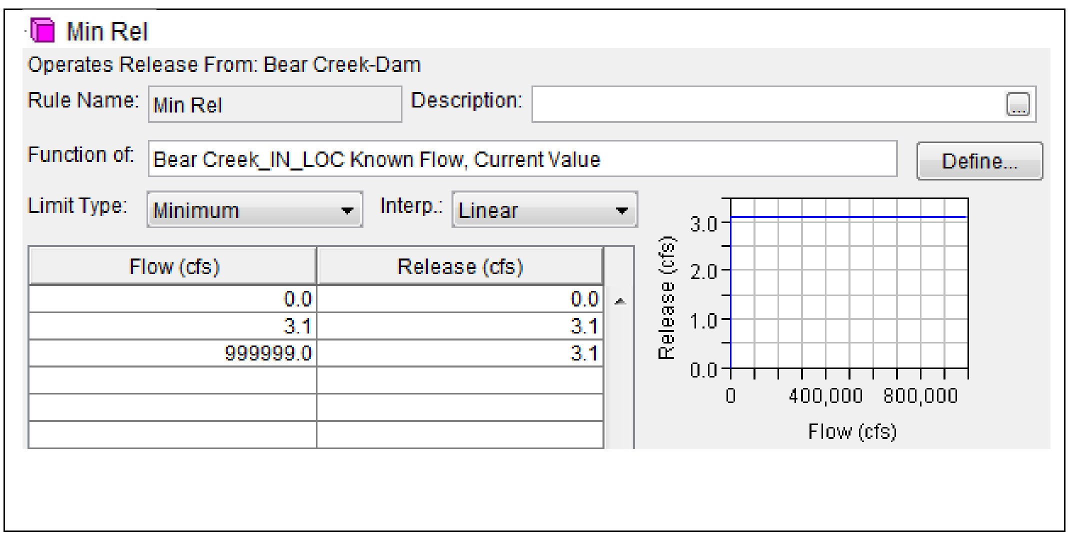

Figure G.17 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Min Rel

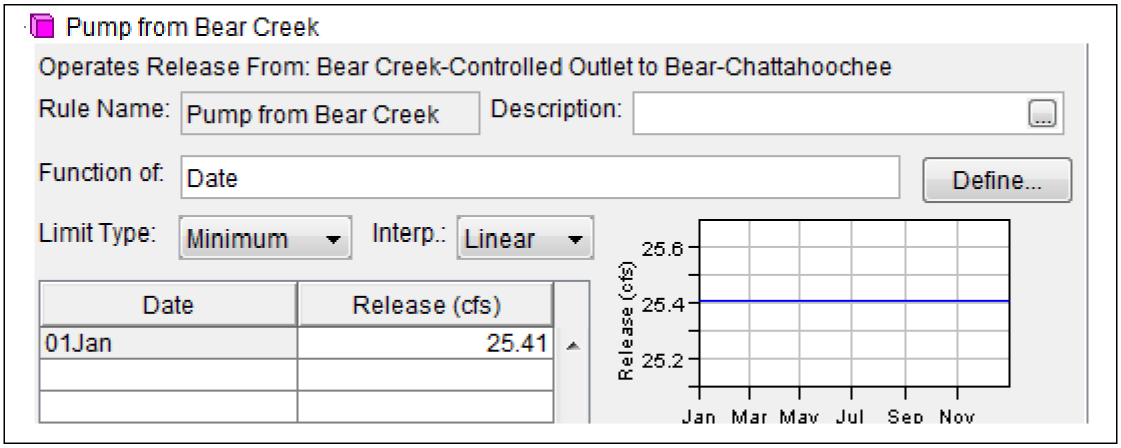

Figure G.18 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Pump from Bear

3. Rule Description

3.1 - Min Rel

This rule (see Figure G.14) represents the minimum required release from the dam which is the sum of a 2 cfs Non-Depletable Flow (NDF) and a 1.1 cfs Minimum Instream Flow (MIF). If the reservoir inflow is less than the stipulated amount, then reservoir inflow will be released.

3.2 - Pump From Bear Creek

This rule (see Figure G.18) represents the daily "safe yield" water supply withdrawal of 25.4 cfs from Bear. The return flow is assumed to be 70% of the diverted amount and is returned to Chattahoochee River. The return flow is specified in the losses definition for the diverted outlet's routing reach (Figure G.19).

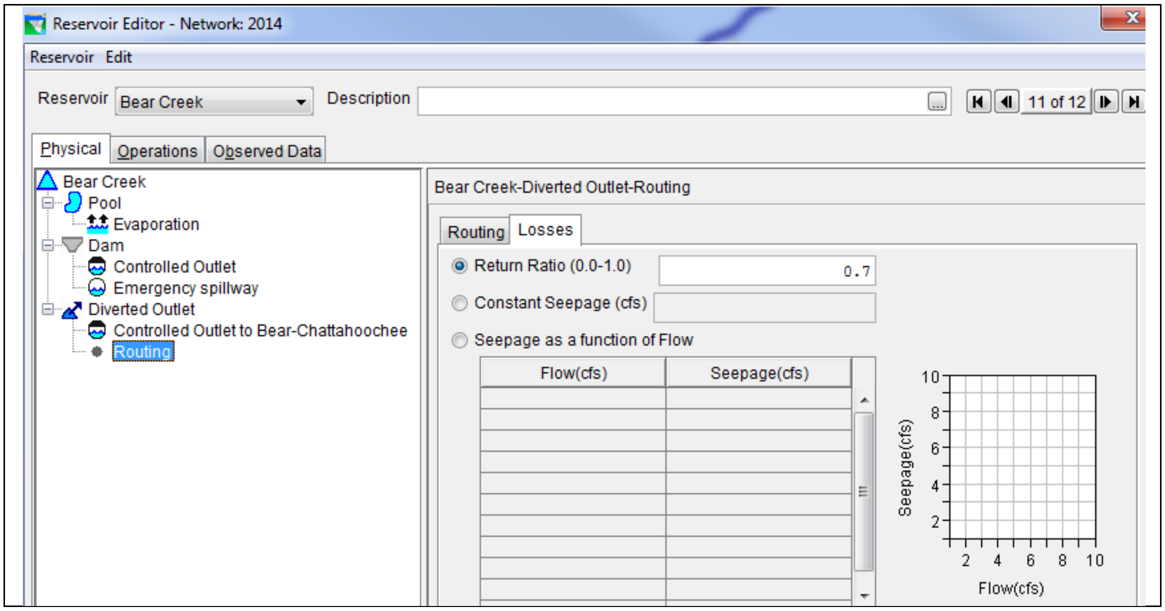

Figure G.19 Bear Reservoir Editor –Physical Tab – Bear – Diverted Outlet - Routing

4. Pump from Chattahoochee River to Bear Creek Reservoir

Pump station diversion was included in the model to supply water to Bear Creek Reservoir. The diversion from the Chattahoochee River is located just upstream of the confluence with Bear Creek. Pumping is assumed to occur whenever the reservoir level falls below 80% of full reservoir storage (EL 750.7906) as long as adequate water remains in the Chattahoochee River. If the reservoir is below 80% of full storage at the end of the day (without diversion pumping), the lesser of the following volumes is computed and delivered to the reservoir:

- The amount of pumping needed to refill the reservoir to 80% capacity
- The designated diversion pumping capacity (21.5 cfs)
- The diversion volume that can be accommodated considering Low Flow Requirements in the Chattahoochee River

The state variable "PumptoBear" is used to determine the amount of pumping in each time step within the restrictions described above. The Pump Station diversion is defined to be a one-to-one function of the state variable value in each timestep. Figure G.20 shows the definition of diversion.

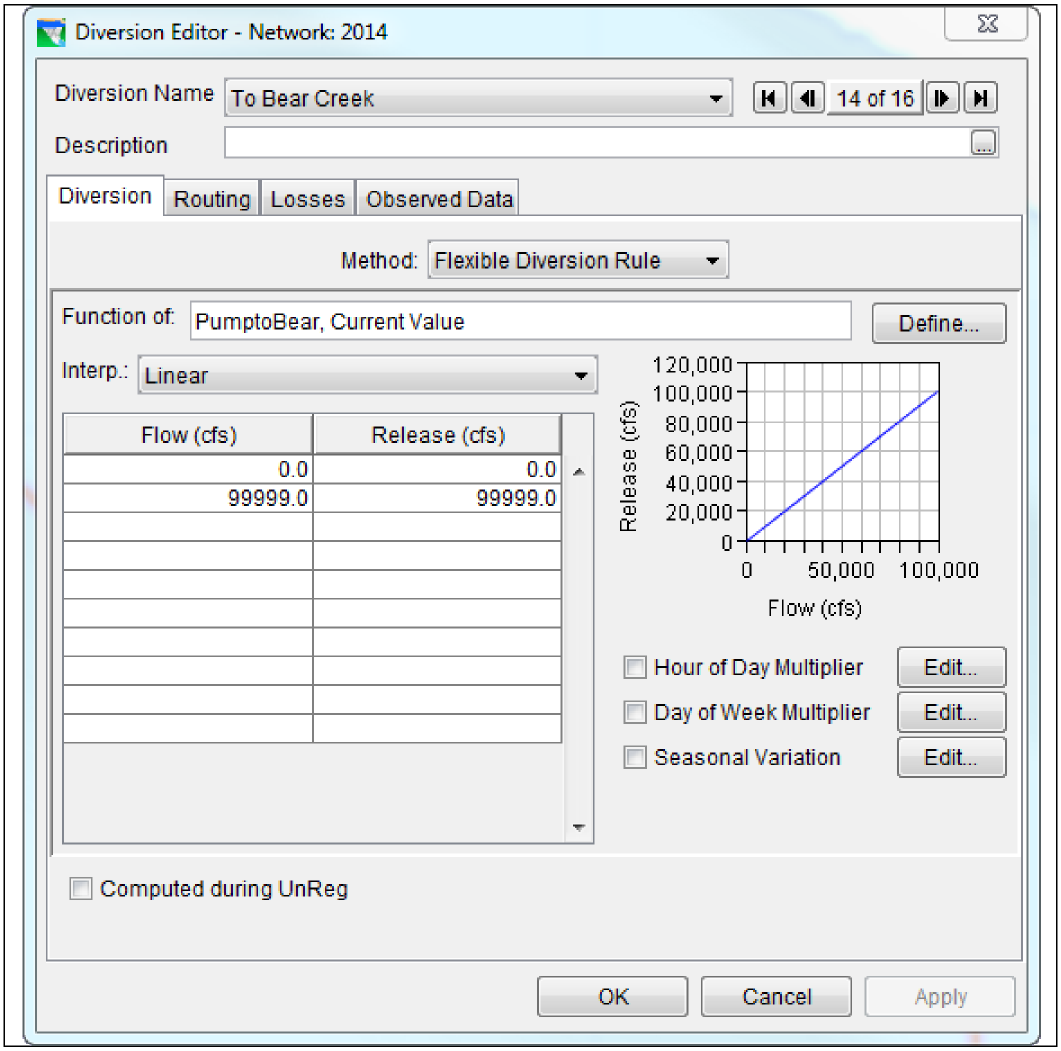

Figure G.20 Diversion Editor – Network 2014: To Bear

D. Alternative Operations – *Same as NO-Action*

The Bear Creek operation set for Bear Creek reservoir is the same for all alternatives and is the same operation set that was used for the NOAction alternative.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix H – State Variables and Utility Scripts

June 2014

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Appendix H – State Variables and Utility Scripts

Table of Contents:

List of Tables:

List of Figures:

Description of State Variables and Utility Scripts (in the ACF Basin HEC-ResSim Model)

I. State Variables Introduction

Reservoir operation rules can be defined using variables that are not natively computed by an HEC-ResSim model. To do so, an HEC-ResSim modeler can create user-defined "state variables" through the Jython scripting interface that is included in the ResSim software. Jython provides the means for accessing and using native model variables and functions in the computation of the user-scripted state variables. Some state variable scripts can even incorporate logic to compute values for other state variables. These complex state variable scripts are refered to as "Master" state variables and the additional state variables computed there-in are refered to as "Slave" state variables. Slave state variables do not require scripts of their own since they are computed by a master script. Similar to model variables, state variables can be used for defining operation rules and IF-Blocks.

The following sections provide explanations of the internal logic of the state variables and describe the intended design purposes and relationships to rules and other state variables. The contents for all primary and master state variable scripts are included in section III of this appendix. Since slave state variables do not employ their own scripts to determine their values, the slave state variables are not included in section III.

II. State Variables

Due to the complex operating objectives and constraints that influence the operation of the ACF reservoirs, a total of 59 state variables were created for use in the ACF model. Figure H.01 shows a list of all the state variables defined for the ACF model; variables highlighted in yellow are the primary or master state variables, while those variables not highlighted are slave state variables that are calculated within the master state variable scripts.

Most of the state variables are defined to establish operating rules for the following operational objectives in the simulations:

- Revised Interim Operations Plan (Flow Target)at Jim Woodruff
- Gulf Sturgeon Spawning Operational Consideration
- Fish Spawning Operational Consideration
- Pumping Operations for the Proposed Water Supply Reservoirs
- Physical Constraints at Walter F George and Jim Woodruff
- Required Energy Tracking

Other state variables are defined to provide additional conditions on the operations or to address modeling limitations or challenges. For example, the state variable "FloodSeasons" was created to identify when the model was in a summer or winter season so that the "right" induced surcharge rule could be activated at West Point Dam. Another state variable, "WestPoint_GCBuffer", was created to manage the oscillations in the results at West Point due to limitations in the tandem operation of the three system reservoirs.

Since the ACF model computes on a daily timestep, most of the state variables, rules, and if-blocks determine their values or states based on information computed in the previous timestep or day, not use information from the current timestep. Using values from 'yesterday' as inputs to the calculations for 'today' simplifies the state variable script implementation since then the data is not a function of today's release decisions. This design reflects the District's procedure for determining today's operations based on conditions observed at the beginning of the workday.

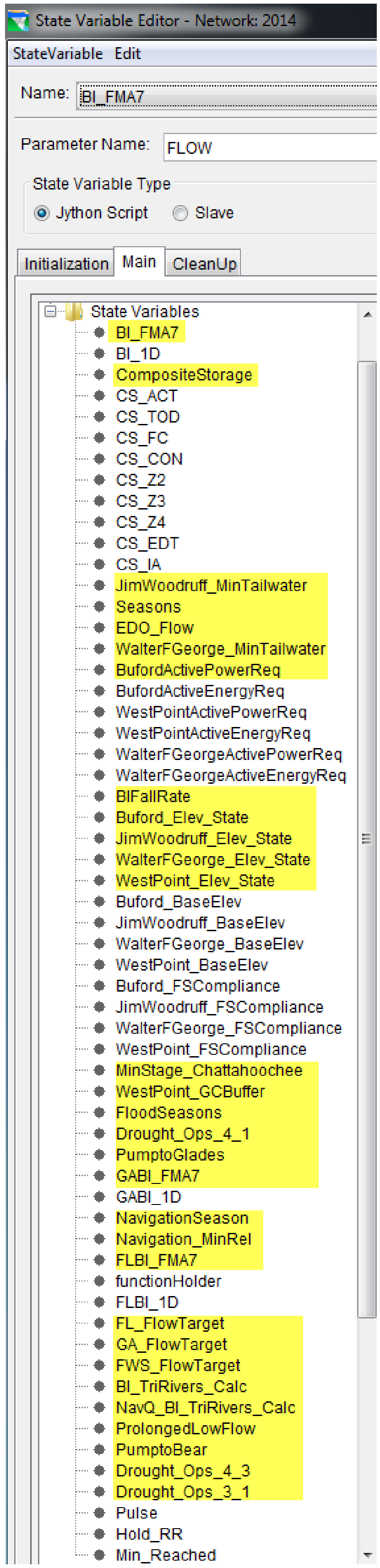


Figure H.01 List of State Variables in the ACF Basin Model

A. State Variables Used for Revised Interim Operations Plan (Flow Target) at Jim Woodruff

The Revised Interim Operations Plan establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table H.01. Details of the proposed action are described in a separate document, entitled "*Description of Proposed Action, Modification to the Interim Operations Plan at Jim Woodruff Dam*, dated May 2012 (USACE, 2012)", hereafter referred to as **RIOP2012** or just **RIOP**.

Table H.01 Proposed Action Modified IOP Releases from Jim Woodruff Dam (source: RIOP2012).

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage
March – May	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and< 34,000	>= 16,000 +50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and< 39,000	>= 11,000 +50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June – November	Zones 1, 2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December – February	Zones 1, 2, and 3	>= 5,000	>= 5,000(Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	>= 4,500	Up to 100% BI > 4,500

1. *CompositeStorage*

This state variable determines in which composite storage zone lies the actual composite storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Because Lake Seminole does not have much storage, the storage of Lake Seminole is not included in the composite storage calculation. Together with the seasons and basin inflow, the composite storage is incorporated into the decisions of minimum releases from Jim Woodruff Dam according to the proposed action described in RIOP 2012 (see Table H.01)

The Composite Storage master state variable script is organized as follows. First, the script determines the current composite storage in the system by summing the current (end of previous timestep) value of active storage in each reservoir. Next, the composite storage zones are computed by summing the current zone storage values from each of the three system reservoirs. And lastly, the current system storage zone is determined by comparing the current composite stoage value to

the current zone storage values. A code value identifying the current system storage zone is stored as the value of the Composite Storage state variable while the values of computed system storage and the composite storage zones are all stored to slave state variables.
The term "composite storage" as used in the ACF model means the sum of the current storage from each reservoir that operates as part of a system to meet the system's objective(s). A related term is "composite storage zone", which means the sum of the storage representing that zone in each reservoir in the system. Composite storage is calculated each day by combining values of storage for Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Composite zones for flood control, conservation, Zone 4, etc, are similarly defined as the sum of the individual zones definited at the three reservoirs. The following storage zones are defined for each reservoir (except EDT – see below):

-	TOD:	Top of dam zone
0.	FC:	Flood control zone
1.	CON:	Conservation zone (top of Zone 1)
2.	Z2:	Zone 2
3.	Z3:	Zone 3
4.	Z4:	Zone 4
5.	EDT:	EDT (Exceptional Drought Trigger) zone
6.	IA:	Inactive zone

The exceptional drought trigger (EDT) zone is a composite zone special to the RIOP. Since it is not defined for each of the three system reservoirs, the script directly contains the ordinates that define it – both for leap year and non-leap year. The year-long EDT curve was provided by SAM (per JEH 9/26/2008). The state variable script contains helper functions for lookup() and interpolation to return the EDT storage for a given day. The logic of the composite storage script treats the EDT as a "zone 5".

After the actual composite storage and composite zone storages are calculated, their values are assigned to the following 8 slave state variables for use in the script, for later reference, and for model analysis. No rules directly utilize them, but saving these intermediate results in state variables generates output in DSS and makes the values visible to user reports and custom plots.

- **CS_ACT**: Actual composite storage
- **CS_TOD**: Composite storage at Top of Dam zone
- **CS_FC**: Composite storage at top of Flood Control zone
- **CS_CON**: Composite storage at top of Conservation zone (top of Zone 1)
- **CS_Z2**: Composite storage at top of Zone 2
- **CS_Z3**: Composite storage at top of Zone 3
- **CS_Z4**: Composite storage at top of Zone 4
- **CS_EDT**: Composite storage at top of the EDT zone
- **CS_IA**: Composite storage at top of Inactive zone

Finally, the script determines where the actual composite storage lies with respect to the defined composite storage zones. The result is a code that indicates which system storage zone the system composite storage is in which is assigned to the state variable, "CompositeStorage", as the state of the composite storage according to the following state definition:

Composite Storage State	Definition
0	Above conservation zone (flood pool)
1	Between top of conservation zone and top of zone 2 (within Zone 1)
2	Within Zone 2
3	Within Zone 3
4	Within Zone 4
5	Within drought zone

This state variable is used to set up minimum release rules for different composite zones according to RIOP2012. Figure H.02 shows an example of the application of state variable CompositeStorage.

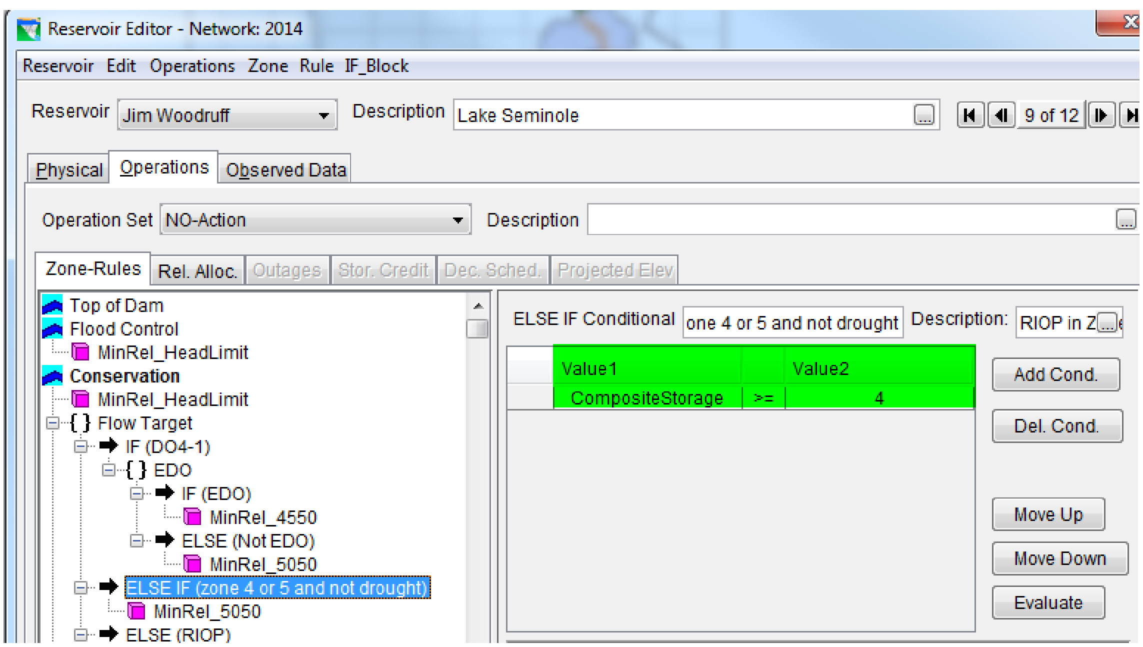


Figure H.02 Example of Applying State Variable "CompositeStorage"

Since the composite storage script is based on information computed in the previous timestep (which does not change during the current timestep), additional computational efficiency was gained by restricting computation of the composite storage variables to only once per day, regardless of the number of passes or iterations involved with determining a regulated flow for the day.

2. *Drought_Ops_4_1, Drought_Ops_4_3, Drought_Ops_3_1 (with EDO_Flow, Hold_RR, and Min_Reached)*

The RIOP incorporates a drought contingency operation (referred to as the drought plan). Under the drought plan, the minimum discharge from Jim Woodruff Dam is determined based on composite storage only (see Table H.01 in RIOP2012). In the drought state, outflows are limited to either the drought operations flow of 5050 cfs (Zone 4 or Zone 3), or the extended drought operations flow of 4550 cfs (Zone5).

In the ACF model three different state variables for drought plan have been defined.These state variables are named “Drought_Ops_4_1”, “Drought_Ops_4_3”, and “Drought_Ops_3_1” which have been used for different operation sets in the model.

- ***Drought_Ops_4_1***

In the state variable named “Drought_Ops_4_1” the drought plan is triggered when composite storage falls below the bottom of Zone 3 into Zone 4 or the exceptional drought trigger zone. This state variable determines when the drought plan is in effect – a value of 1 is “true” or “on” and a value of 0 is “False” or “off”. The “Drought_Ops_4_1” state variable script also sets the value of a companion (slave) state variable named “EDO_Flow”) to 1 or 0 (true or false). The conditional rules at Jim Woodruff use these values to determine releases.

At the beginning of each month, the “Drought_Ops_4_1” state variable determines whether the drought plan is in effect – then it holds the drought operations state throughout the rest of the month. When calculated at the beginning of the month, the “Drought_Ops_4_1” script recalls its own value for the final day of the previous month (“DOps_state_prev”), and retrieves the value of the Composite Storage Zone for today (“CS_state”). These two pieces of information are used in a series of conditional expressions in the state variable script to set the current day’s values for DroughtOperations and EDO_Flow.

If in Composite Storage Zone 5, then Drought_Ops_4_1=true and EDO_Flow=true.
If in Composite Storage Zone 4, then Drought_Ops_4_1=true and EDO_Flow=false.
If in Composite Storage Zone 3 and Drought_Ops_4_1=true for last month, then Drought_Ops_4_1=true and EDO_Flow=false.
If in Composite Storage Zone 2 and Drought_Ops_4_1=true for last month, then Drought_Ops_4_1=true and EDO_Flow=false.
If in Composite Storage Zone 1, then Drought_Ops_4_1=false and EDO_Flow=false.

The logic above reflects two trigger states – when to turn on Drought Operations and when to turn it off. As previously mentioned, it is turned on when the composite storage falls into Composite Zone 4, but the other trigger is when to turn it off. In this implementation, drought operations remain in effect until the composite storage returns to composite storage Zone 1 (when evaluated at the first day of a month). Figure H.03 shows the Drought Composite Triggers in "Drough_Ops_4_1" state variable.

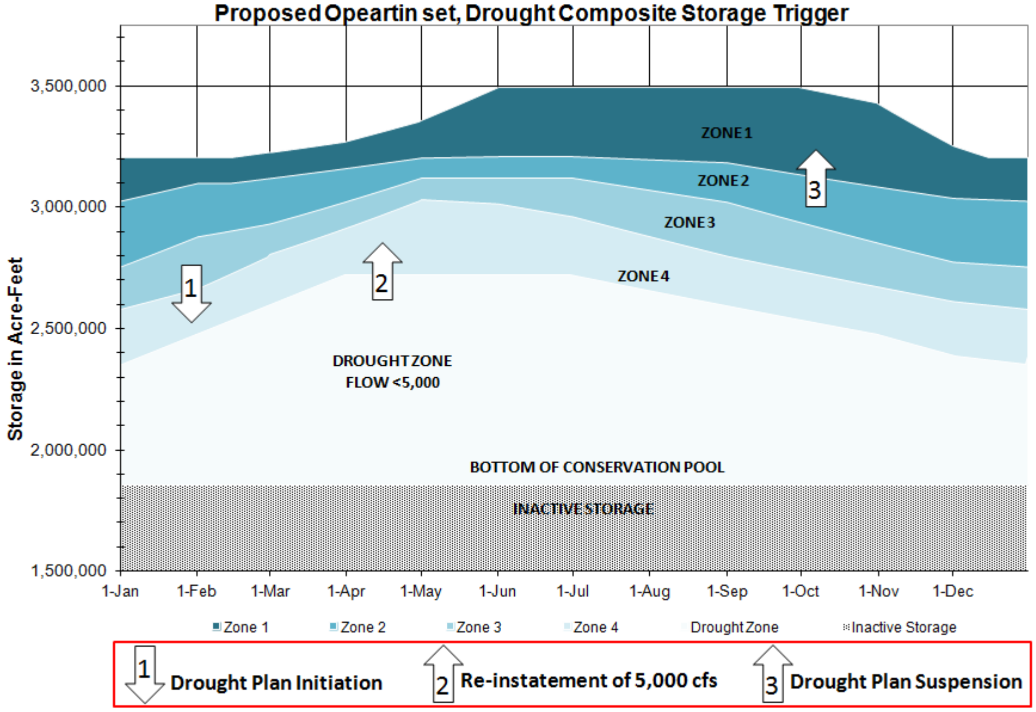


Figure H.03 Drought Composite Storage Triggers in State Variable "Drought_Ops_4_1"

- ***Drought_Ops_4_3***

The "Drought_Ops_4_3" state variable turns on drought operation once composite storage falls into Composite Zone 4 and remains in effect until the composite storage returns to Composite Zone 3.

If in Composite Storage Zone 5, then Drought_Ops_4_3=true and EDO_Flow=true.
If in Composite Storage Zone 4, then Drought_Ops_4_3=true and EDO_Flow=false.
If in Composiste Sorage Zone 3 or higher, then Drought_Ops_4_3=false and EDO_Flow=false.

Figure H.04 shows the Drought Composite Triggers in "Drough_Ops_4_3" state variable.

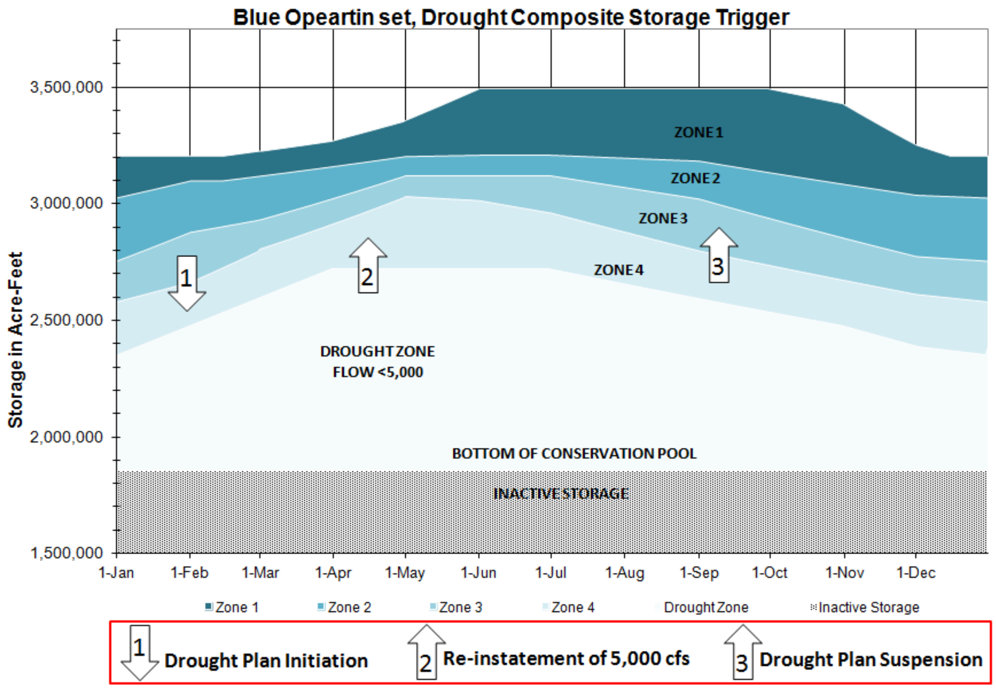


Figure H.04 Drought Composite Storage Triggers in State Variable “Drought_Ops_4_3”

- ***Drought_Ops_3_1***

The “Drought_Ops_3_1” state variable turns on drought operations when the composite storage falls into Composite Zone 3 and remains in effect until the composite storage returns to Composite Zone 1.

If in Composite Storage Zone 5, then Drought_Ops_3_1=true and EDO_Flow=true.
If in Composite Storage Zone 4, then Drought_Ops_3_1=true and EDO_Flow=false.
If in Composite Storage Zone 3, then DroughtOps_3_1=true and EDO_Flow=false.
If in Composite Storage Zone 2 and Drought_Ops_3_1=true for last month, then Drought_Ops_3_1=true and EDO_Flow=false.
If in Composite Storage Zone 1, then Drought_Ops_3_1=false and EDO_Flow=false.

Figure H.05 shows the Drought Composite Triggers in “Drough_Ops_3_1” state variable.

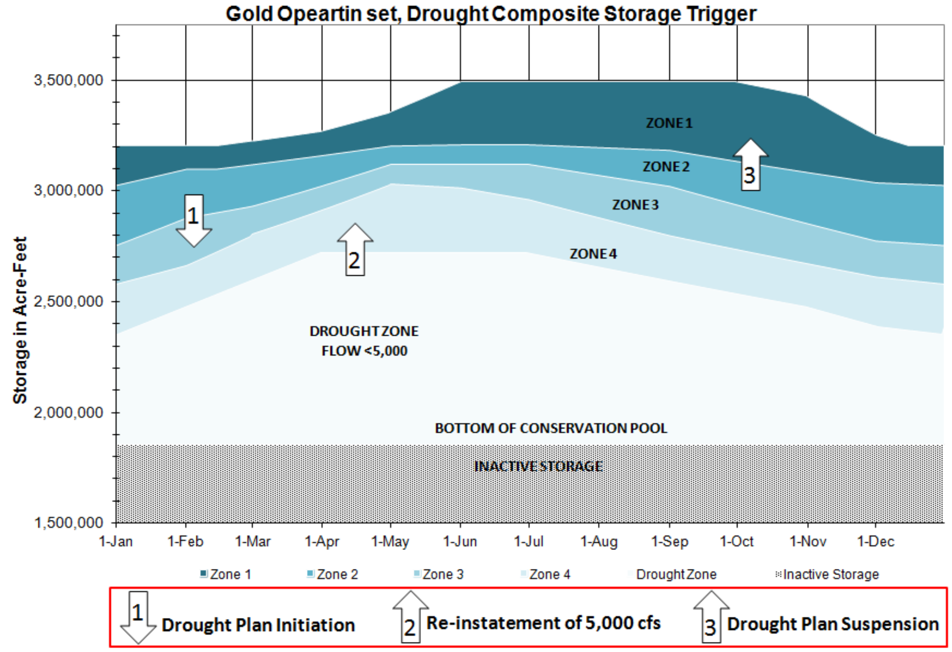


Figure H.05 Drought Composite Storage Triggers in State Variable "Drought_Ops_3_1"

The state variables for Drought Operation determine the value of two more companion/slave state variables named "Hold_RR" and "Min_reached". These additional state variable are used to maintain the RIOP-Falling Ramp Rate rule when Drought operation first occurs until the target minimum flow is reached, at which point the RIOP-Falling Ramp Rate is suspended. The target minimum flow is 5050 cfs during Drought Operation (DO) and 4550 cfs during Exceptional Drought Operation (EDO).

These state variables and their companions are used to activate appropriate rules under drought operations at Jim Woodruff Dam according to the RIOP. Figure H.06 shows an example of the application of "Drought_Ops_4_1" state variable. Figure H.07 shows an example of the application of "Hold_RR" state variable.

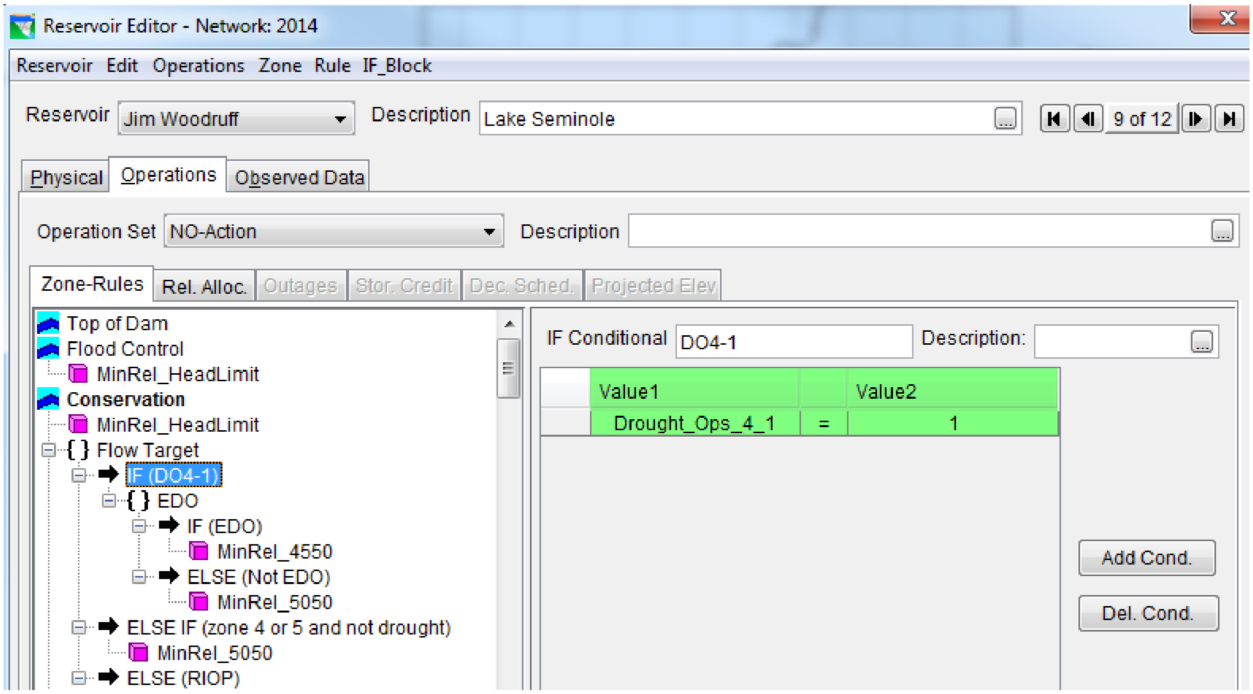


Figure H.06 Example of Applying State Variable "Drought_Ops_4_1"

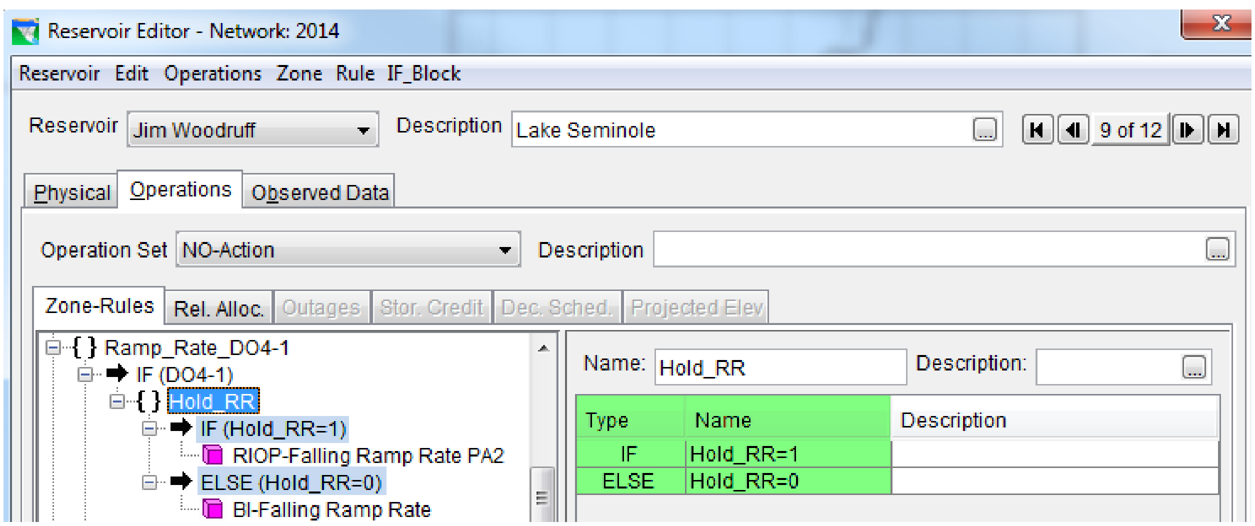


Figure H.07 Example of Applying State Variable "Hold_RR"

3. *ProlongedLowFlow*

This state variable determines whether or not the system is within the prolonged low flow situation. The prolonged low flow situation is triggered when flows from Jim Woodruff Dam have been less than 7,000 cfs for 30 days. The normal situation resumes when flows have been greater than 10,000 cfs for at least 30 days. If the "ProlongedLowFlow" state variable is on pool should follow the BI-Falling Ramp Rate. An example application of the ProlongedLowFlow state variable is illustrated in Figure H.08.

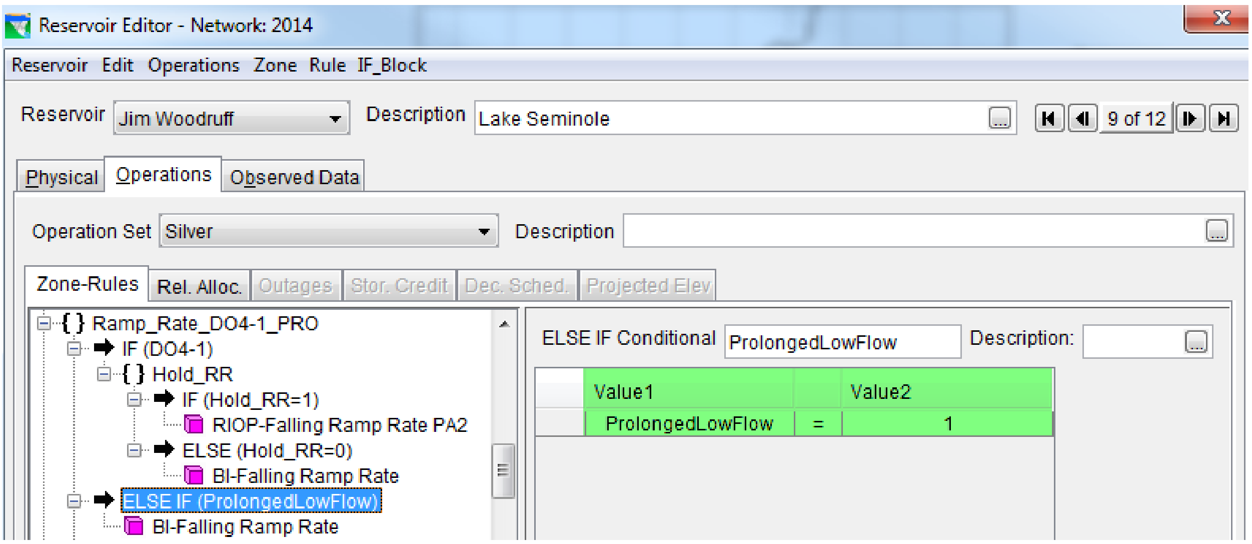


Figure H.08 Example of Applying State Variable "ProlongedLowFlow"

4. *Seasons*

This state variable determines the season of the current run time step. A value of 1 indicates that the current time step is in the "spawning" season between March 1 and May 31, a value of 2 indicates "non-spawning" season between June 1 and November 30, and a value of 3 means "winter" season from December through February.

This state variable is used in the conditional expression of an If Block in the operation set to determine the active minimum release rule for Jim Woodruff Dam according to the seasons, composite storage, and basin inflow (Table H.01). Figure H.09 shows its use in defining the minimum flow releases from Jim Woodruff Dam.

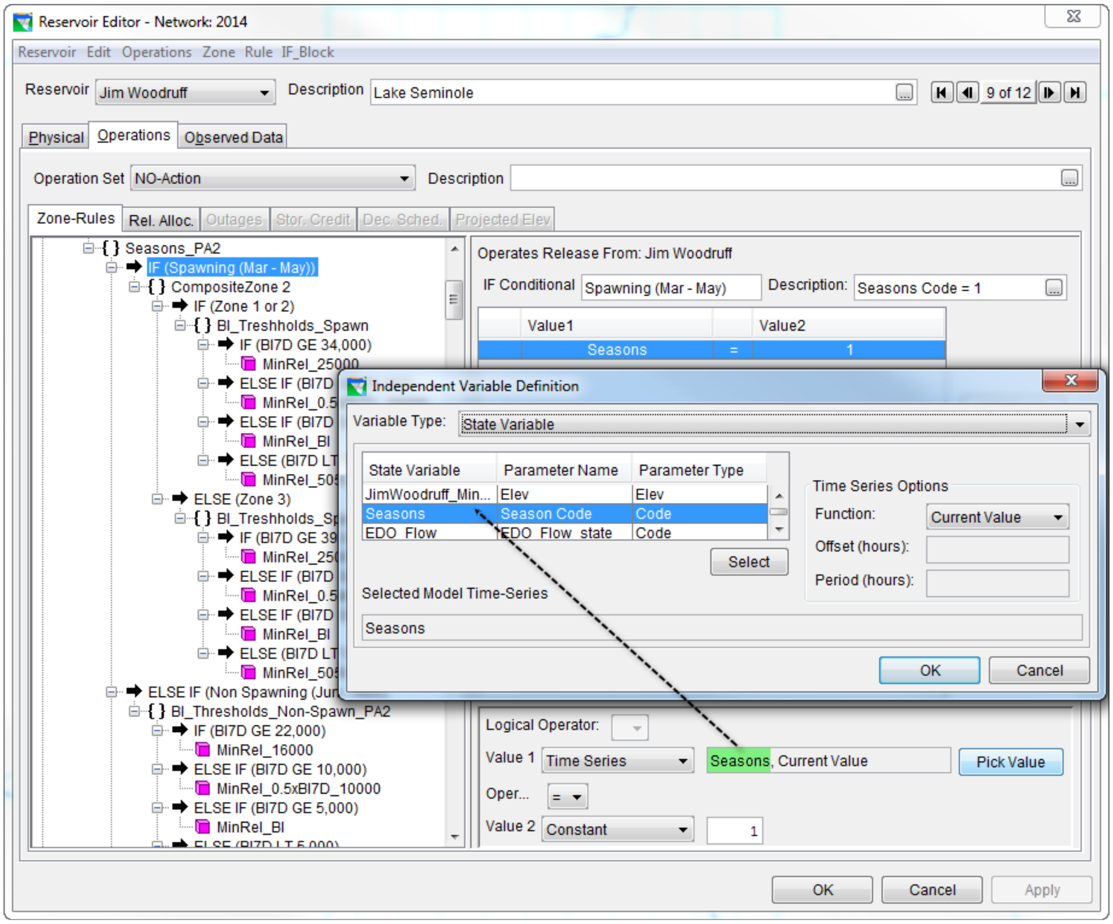


Figure H.09 Example of Applying State Variable "Seasons"

5. BIFallRate

This state variable implements the requirement for the fall rates (the vertical drop in river stage that occurs over a given period) under the drought operations as described in the RIOP. The fall rate for river stage needs to match the 1-day basin inflow fall rate. The script first calculates the base inflow fall rate. It then determines the release from Jim Woodruff for the current day such that the decrease in the release from the previous day matches the 1-day basin inflow fall rate. The required release is used as a minimum release rule at Jim Woodruff Dam. This rule is applied when Basin inflow falls. When Basin Inflow rises for flows less than 22,000 cfs, the falling ramp rate is limited to 2 ft fall rate. The required release is used as a minimum release rule at Jim Woodruff Dam. Figure H.10 shows an example of its application.

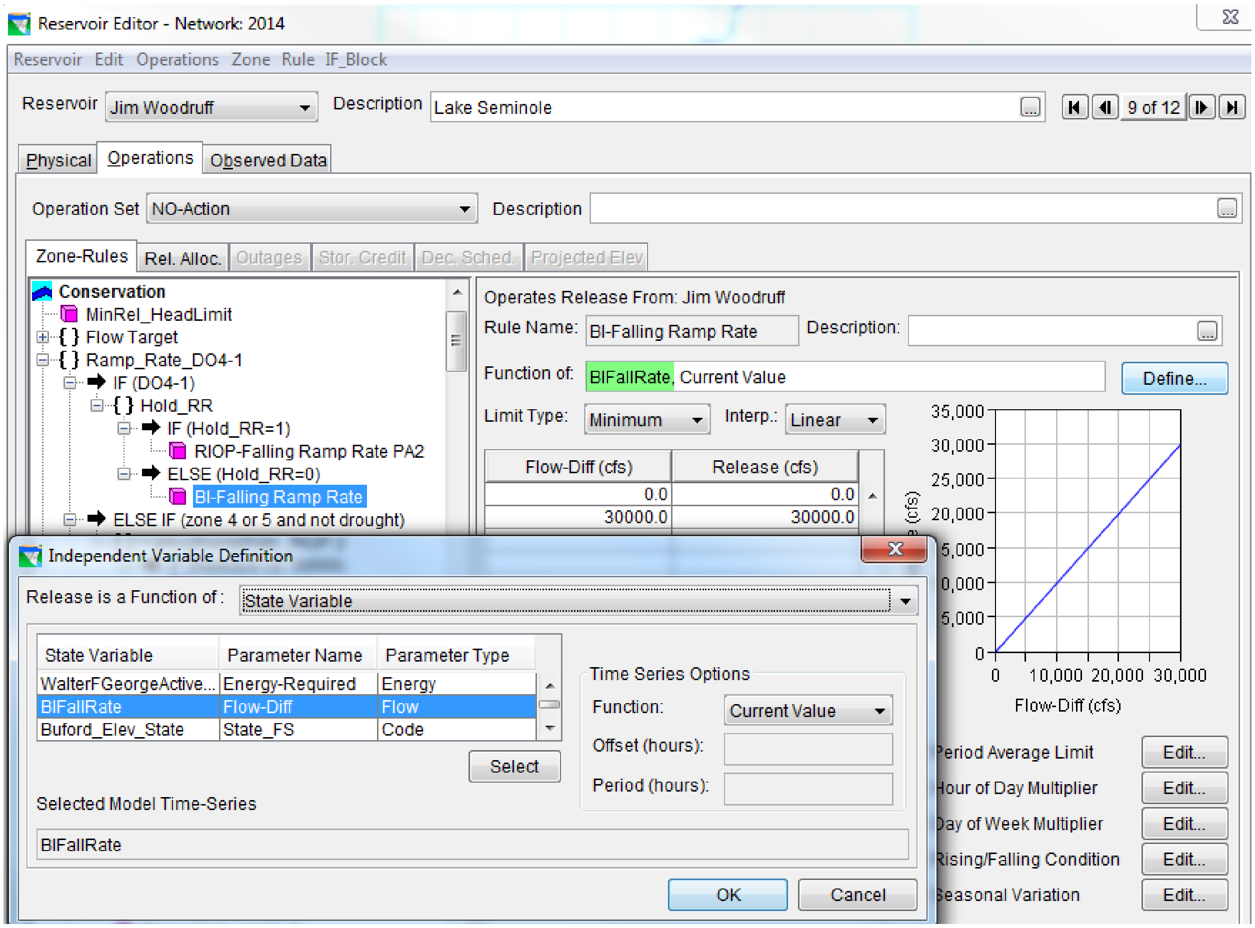


Figure H.10 Example of Applying State Variable "BIFallRate"

6. BI_FMA7(with BI_1D)

This state variable represents the 7-day forward moving average basin inflow to the ACF basin up to Jim Woodruff Dam.

The script begins by computing the daily basin inflow to Jim Woodruff Dam at the current time step as a summation ofthe "local inflows" to Buford, West Point, WF George, and Jim Woodruff on the previous day. The daily (one day) basin inflow is stored to the slave state variable "BI_1D". The local inflow to Buford is represented by the computed net inflow to Lake Sidney Lanier. The local inflow into the remaining COE projects is successively calculated as the net inflow to the downstream pool minus the total outflow from the upstream pool.

Similarly, the 7-day moving average basin inflow to Jim Woodruff Dam at the current time step is a summation of 7-day moving average local inflows to Buford, West Point, WF George, and Jim Woodruff, which are calculated using the previous 7 days of net inflows to each reservoir and the previous 7 days of outflows from each dam. Similar to the Composite Storage state variable, the calculation of the basin inflow does not involve any model variables at the current time step. Therefore, the computation efficiency significantly increases. The methodology and some background for calculating the basin inflow are described in a separate powerpoint document (file name: BasinInflowComputation.ppt). It should be noted that in the current daily model, channel routing has been implemented. For details, refer to the main text of the report.

This state variable is used to specify minimum release rules for Jim Woodruff Dam. Figure H.11 shows an example of its application.

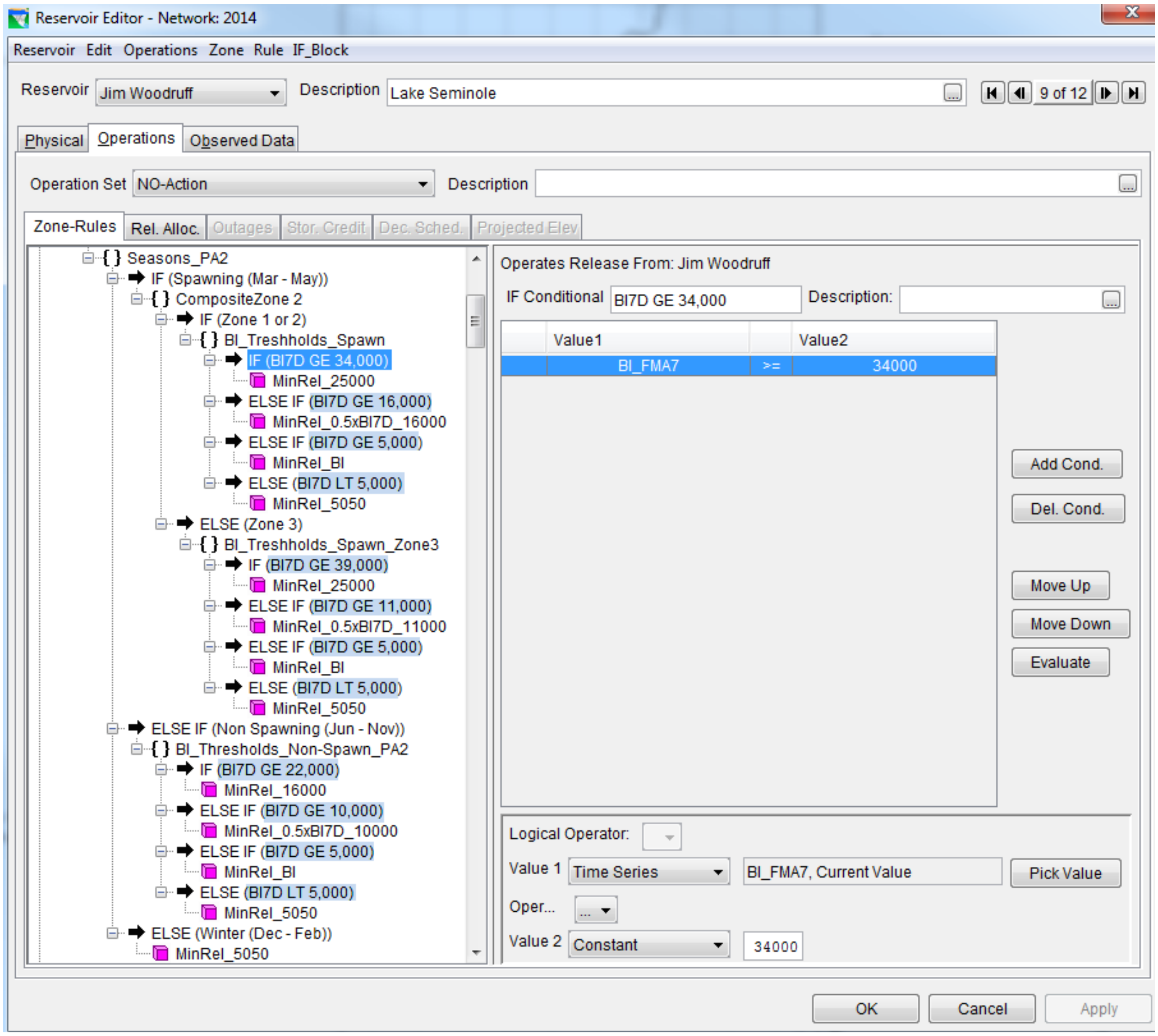


Figure H.11 Example of Applying State Variable "BI_FMA7"

7. FLBI_FMA7 (with FLBI_1D)

The RIOP method of calculating basin inflow does not consider large depletions from water consumption and reservoir evaporation.
Florida proposed Revised Basin Inflow (RBI) calculation includes depletions used in the reservoir model, in order to better represent "true" basin inflow.

RBI estimates depletions according to three climatological classifications of years (Wet, Normal, and Dry), as shown in Table H.02. Depletions used in Corps model include municipal and industrial demands, agricultural demands, and Federal reservoir evaporation which are defined for given month and type of year and shown in Table H.03.
method of calculating basin inflow is a "net" calculation that does not represent true basin inflow, because large depletions from water consumption and reservoir evaporation are not accounted for.

Table H.02 Types of Years

1939	N	1958	W	1977	N	1996	N
1940	N	1959	N	1978	N	1997	N
1941	D	1960	N	1979	N	1998	N
1942	N	1961	N	1980	N	1999	D
1943	N	1962	N	1981	D	2000	D
1944	W	1963	N	1982	N	2001	N
1945	N	1964	W	1983	N	2002	N
1946	W	1965	W	1984	N	2003	W
1947	W	1966	N	1985	N	2004	N
1948	W	1967	N	1986	D	2005	N
1949	W	1968	D	1987	N	2006	D
1950	N	1969	N	1988	D	2007	D
1951	D	1970	N	1989	N	2008	N
1952	N	1971	W	1990	D	2009	N
1953	W	1972	N	1991	W	2010	N
1954	D	1973	W	1992	N	2011	D
1955	D	1974	N	1993	N	2012	D
1956	D	1975	W	1994	W		
1957	N	1976	N	1995	N		
W=Wet Years, N=Normal Years, D=Dry Years							

Table H.03 Summary of depletions (cfs) to basin inflow upstream of Woodruff Dam used in Florida Basin Inflow

	Municipal and Industrial				Agriculture				Reservoir Evaporation				Total			
	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years
Jan	334	300	331	312	1	1	0	1	-183	-279	-415	-273	152	22	-85	40
Feb	302	263	295	276	23	3	0	7	-78	-159	-168	-141	246	107	127	142
Mar	345	254	257	276	94	41	31	53	153	-39	-197	-12	592	257	92	316
Apr	453	332	317	359	212	103	83	126	567	389	194	408	1231	825	594	883
May	615	457	340	480	586	344	292	395	672	573	338	569	1873	1374	970	1444
Jun	715	494	406	536	793	439	368	514	666	485	329	509	2173	1419	1104	1559
Jul	700	525	382	550	903	587	506	651	477	387	-61	356	2080	1499	827	1557
Aug	710	532	429	562	955	578	486	658	484	409	321	416	2149	1519	1236	1634
Sep	592	500	485	520	672	328	259	401	418	358	478	386	1682	1186	1222	1307
Oct	552	466	461	486	251	130	105	156	316	315	265	310	1119	912	831	951
Nov	435	378	388	392	192	90	70	112	33	-128	66	-67	660	339	525	437
Dec	399	337	358	354	168	79	62	98	-130	-186	-63	-158	437	230	356	293
Average	514	404	371	426	406	228	180	266	284	179	91	193	1204	811	652	885

Source: USFWS Biological Opinion May 22, 2012

The state variable FLBI_FMA7 represents the proposed Florida 7-day forward moving average basin inflow to the ACF basin up to Jim Woodruff Dam. The state variable script first sets the 1-day basin inflow and 7-day forward moving average as the current "BI_1D" and "BI_FMA7" variables. Then using a lookup table, the current water year is set in terms of "WetYears," "DryYears," and "NormYears" based on the period of record as shown in Table H.02. Within another lookup table, the water demand is set in terms of "Wet_demand," "Dry_demand," and "Norm_demand" according to current type of year and month as shown in Table H.03. If the current year is a "WetYear," the current 1-day and 7-day basin inflows are increased by the "Wet_demand". If the current year is a "DryYear," the basin inflows increase by the "Dry_demand." Otherwise, basin inflows increase by the "Norm_demand".

The FLBI_1D state variable corresponds to the 1-day basin inflow to Jim Woodruff Dam. It is calculated as an intermediate value in the script for FLBI-FMA7 (7-day moving average basin inflow to Jim Woodruff Dam), and stored as a separate state variable, named "FLBI_1D".

8. GABI_FMA7 (with GABI_1D)

The GABI_FMA7 state variable computes the 7-day forward moving average of the basin inflow to Jim Woodruff dam, based on the Georgia proposal. It is the sum of the 7-day average difference in flow in and out for each project.
The GABI_1D state variable corresponds to the 1-day basin inflow to Jim Woodruff Dam. It is calculated as an intermediate value in the script for GABI-FMA7 (7-day moving average basin inflow to Jim Woodruff Dam), and stored as a separate state variable. This state variable is the same as "BI_FMA7" state variable except that it does not consider the lagging in the basin inflow computation. The formula provided is listed below:

> Basin Inflow = Chattahoochee River flow + Lanier change in storage + West Point change in storage + WF George change in storage + Jim Woodruff change in storage

9. FL_FlowTarget

The operational requirements for Florida alternative is represented in Table H.04. The FL_FlowTarget state variable computes the proposed Florida daily flow target from Jim Woodruff. The objective is to get Chattahoochee flows as close as possible to natural flows. The release trigger based on RBI instead of current Basin Inflow that includes net consumption in the basin above Jim Woodruff. A set of daily minimum flow are based on historic exceedance values that vary with season, composite storage zone and inflow conditions; dry or normal/wet. An additional release amount of 50% of available RBI over the minimum release is added to the minimum. Additional releases are not required when composite storage is in the drought zone (still under development at the time public comments were received).   There are no additional rules for minimum flow reductions during drought operations. Minimum flows are simply lower for lower composite storage zones. When composite storage is in higher zone, minimum flows are higher.

The script first sets the current 75%, 80%, 85%, 90%, 95% and 99% chance exceedance flow values using a lookup table. The Florida flow requirement is dependent on the average previous 7-day composite storage zone of the system and whether the average previous 7-day Florida basin inflow is expected to be in the Mid to high range (1) or low range (0). If the average 7-day Florida basin inflow (UF_state) is greater than the current 75% exceedance of 7-day rolling average unimpaired flow then the basin inflow is considered in Mid to high range, otherwise it is considered in Low range.

When the system is in composiste storage zones 3 or 4, and the basin inflow is considered in low range the flow target is reduced during December, January, and February. When the system is in EDO zones, in all conditions of basin inflow the flow target is reduced during January-May. During June-December before the target flow is determined, several intermediate variables are computed to check for various system states. The net 7-day basin inflow (BI7D) needs to be checked whether it is greater than 10,000 cfs or not. The 60-day average flow in the Chattahoochee below Jim Woodruff (Chatt_state_60) needs to be check whether it is less than 6,000 cfs or not. If BI7D is greater than 10,000 cfs and Chatt_sttae_60 is less than 6,000 cfs then additional release will be 50% of any Net BI_FMA7 that exceeds minimum flow indicated in column three for the EDO zone in Table H.04.

Table H.04 Florida Flow Target

If Composite Conservation Storage-P7 is:	And if RBI-P7 is in:	The average flow release-U7 is:	
		Minimum Flow	Plus additional Flow
Zone 1 or 2	Mid to High range	80% exceedance-U7	50% of any RBI-P7 that exceeds minimum flow
	Low range	85% exceedance-U7	50% of any RBI-P7 that exceeds minimum flow
Zone 3 or 4	Mid to High range	90% exceedance-U7 with a minimum of 6,000 cfs	50% of any RBI-P7 that exceeds minimum flow
	Low range	95% exceedance-U7 with a minimum of 5,000 cfs	Mar-Nov: 50% of any RBI-P7 that exceeds minimum flow Dec-Feb: No additional release required.
EDO	All Conditions	99% exceedance-U7 with a minimum of 5,000 cfs	No additional release required except 50% of storm pulses under certain conditions*

*Conditions when 50% of storm pulses are released are under review and will be include at a later time.

Terms: P7=for the last seven days;U7=for the upcoming 7 days; RBI= revised Basin Inflow
Mid to High range=>75% exceedance of 7-day rolling average unimpaired flow(1939-2008);
Low range=<75% exceedance of 7-day rolling average unimpaired flow(1939-2008)

The Florida Flow Target rule establishes minimum outflows from Jim Woodruff as a function of composite storage, and basin inflow. Figure H.12 shows an example of application of “FL_FlowTarget” state variable.

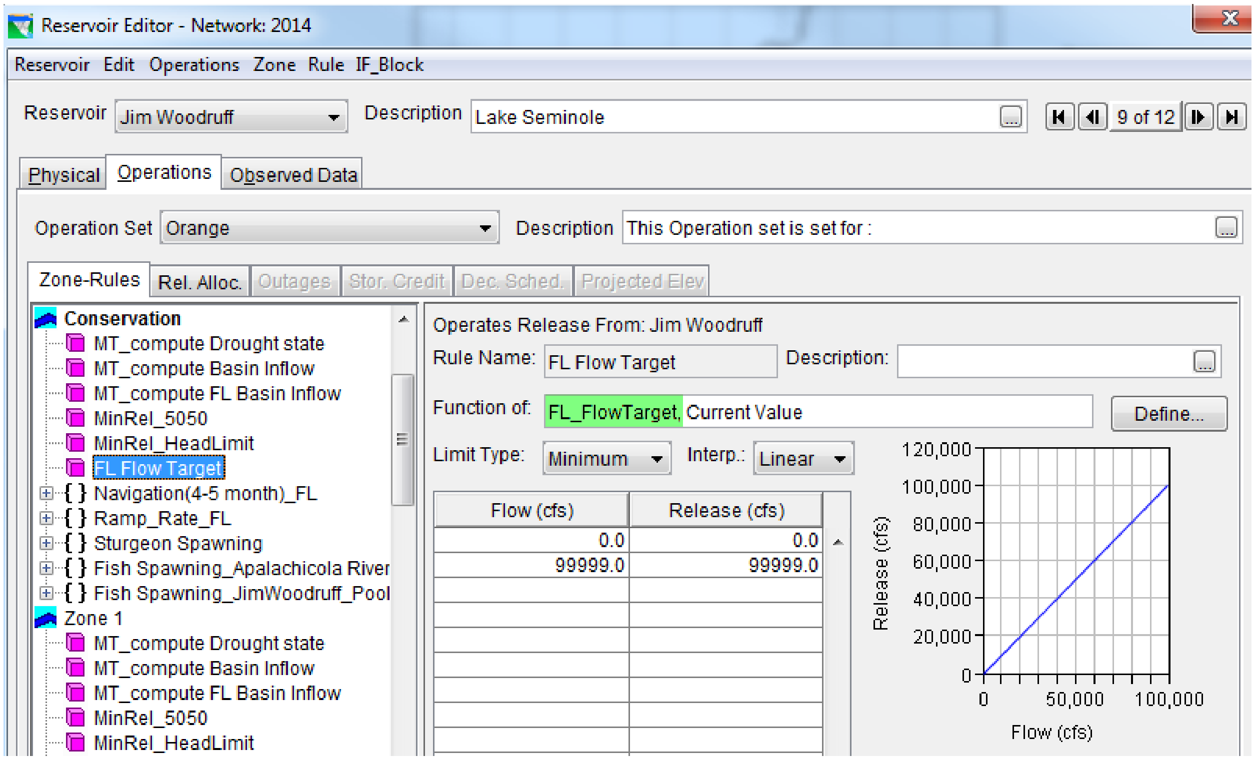


Figure H.12 Example of Applying State Variable "FL_FlowTarget"

10. GA_FlowTarget

The operational requirements for Georgia alternative is represented inTable H.05 . The GA_FlowTarget state variable computes the proposed Georgia daily flow target from Jim Woodruff.The state variable separates the year into 4 seasons: Mar, Apr-May , Jun-Nov , and Dec-Feb and specifies the minimum flow from Jim Woodrudff based on the condtions that are shown in Table H.05.

Table H.05 Georgia Flow Target

Months	Total storage in Reservoirs	Basin Inflow(BI) (cfs) or other conditions	State Line Flow (SLF) (cfs)	Basin Inflow to be stored (cfs)
March	Zone 1,2, and 3	NA	>=6,500	Entire or partial BI above SLF, subject to available Storage capacity
April 1-May 31	Zone 1,2, and 3	Cumulative BI in February and March > 2.45 million acre-feet	Maintain Q=min(10,500, min(observed moving 30-day flow))	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if BI>=10,500 If BI<10,500 and >= 5,000 If BI <5,000	>= 10,500 >= BI >= 5,000	
In sub-period April 16-April 30		Lanier>1066' , and West Point>632' , and Walter F George >187'	Maintain Q=min(22,500,max(10,500, min(observed March 17-April 15 daily flow)))	Entire or partial BI above SLF, subject to available Storage capacity
June-Nov	Zone 1,2, and 3	BI>= 10476 & previous seven day's Chattahoochee gage flow<5100	>= High Pulse flow (June 14,850, July 15,500, August 14,400, September 11,200, October 10,100, November 10,500), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		BI>= 7181 and < 10476 & previous seven day's Chattahoochee gage flow<5100	>= Small Pulse flow (June 11,600, July 11,500, August 11,100, September 8,620, October 7,420, November 7,980), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		Other Situation	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	>=4,500	Entire or partial BI above 5,000 subject to available Storage capacity

The following is a detailed description of the flow target by season.

March 1 through March 31
Georgia Flow Target maintains a minimum flow requirement in the Apalachicola River at Chattahoochee, Florida for March of 6,500 cfs. March historically has been the wettest month in the ACF Basin, and monthly average flow in the Apalachicola River at the Chattahoochee gage during March is expected to exceed 6,500 cfs.

April 1 through May 31
Conserve system storage to meet water supply and other authorized reservoir purpose the observation of February and March flow provides a good basis for determining subsequent flow and a sustainable level of spawning season habitat. Georgia Flow Target use cumulative February and March basin inflow (BI) to determine if the ACF Basin is likely to be under drought conditions. When cumulative BI for February and March is higher than 2.45 million acre-feet, the basin is considered to be under normal spring hydrologic conditions. When cumulative BI is lower than 2.45 million acre-feet, the basin is likely to be either in drought or approaching drought conditions. When the basin is under normal spring hydrologic conditions, we set release into the Apalachicola River at the lower of 10,500 cfs or the moving minimum of the previous 30 days. A 10,500 cfs flow provides about 85% of all the available sturgeon spawning habitat at the amount of inundation specified in the 2012 Biological Opinion. When the basin is under likely drought conditions, as determined by the cumulative BI, release into the Apalachicola River is set at 10,500 cfs when BI is higher than 10,500 cfs, or BI if it is lower than 10,500 cfs, but not lower than 5,000 cfs. This assures that a continuous 30-day inundation of a large portion of the spawning habitat is achieved.

Sub-period April 16 through April 30
1. When Lanier elevation is above 1066 feet, West Point elevation is above 632 feet, and Walter F. George is above 187 feet, the Georgia Contemplation uses the following procedure to determine releases to support flood plain connectivity:
a. Determine the minimum level of flow that has been sustained in the previous 30 days
(March 17 through April 15);
b. Compare this sustained flow with 10,500 cfs, and take the larger one; and c. Compare the flow obtained in step b with 22,500 cfs, and take the lower one as the level of flow to be sustained for the sub-period.
2. When Lanier, West Point, or Walter F. George is below the elevation levels specified above, the above support of flood plain connectivity will not be provided.
This approach makes good use of naturally-higher flow in the first half of April and provides limited support from storage in the second half of April to achieve sustainable flow support for flood plain connectivity for up to 30 days.

June 1 through November 30
The Georgia Flow Target maintains a 5,000 cfs minimum flow requirement as the base flow for the non-spawning season. When BI rises above the 25th percentile for the period, roughly 7,200 cfs, a pulse flow lasting one day and corresponding to the 25th percentile daily flow can be made. Table H.06 shows the values for Georgia Low Pulse Flow.

Table H.06 Georgia Low Pulse Flow

Month	25^{th} Percentile Flow Pulse (cfs)
June	11600
July	11500
August	11100
September	8620
October	7420
November	7980

When BI rises above median for the period, roughly 10,500 cfs, the Georgia Flow Target could provide a pulse flow lasting one day and corresponding to median daily flow. Table H.07 shows the values for Georgia Low Pulse Flow.

Table H.07 Georgia High Pulse Flow

Month	Median Flow Pulse (cfs)
June	14850
July	15500
August	14400
September	11200
October	10100
November	10100

FWS has mentioned benefits of having pulse flows in the non-spawning season (June through November), including elevating dissolved oxygen, removing debris, and providing food sources to living organisms. This 1-day pulse flow attempts to provide such benefit.

Using one-day BI better enables triggering of higher pulses than 7-day average BI with an interval of seven days between any two consecutive pulses. A second pulse flow would not take place until seven days after the previous one and the 1-day BI meets the above stated conditions,

December 1 through February 28
The Georgia Flow Target only minimum flow requirement in the Apalachicola River at the Chattahoochee gage is 5,000 cfs. Any BI beyond this minimum flow requirement is stored to replenish system storage, to the extent possible.

The Georgia Flow Target rule establishes minimum outflow from Jim Woodruff as a function of month,composite storage, and basin inflow. Figure H.13 shows an example of application of “GA_FlowTarget” state variable.

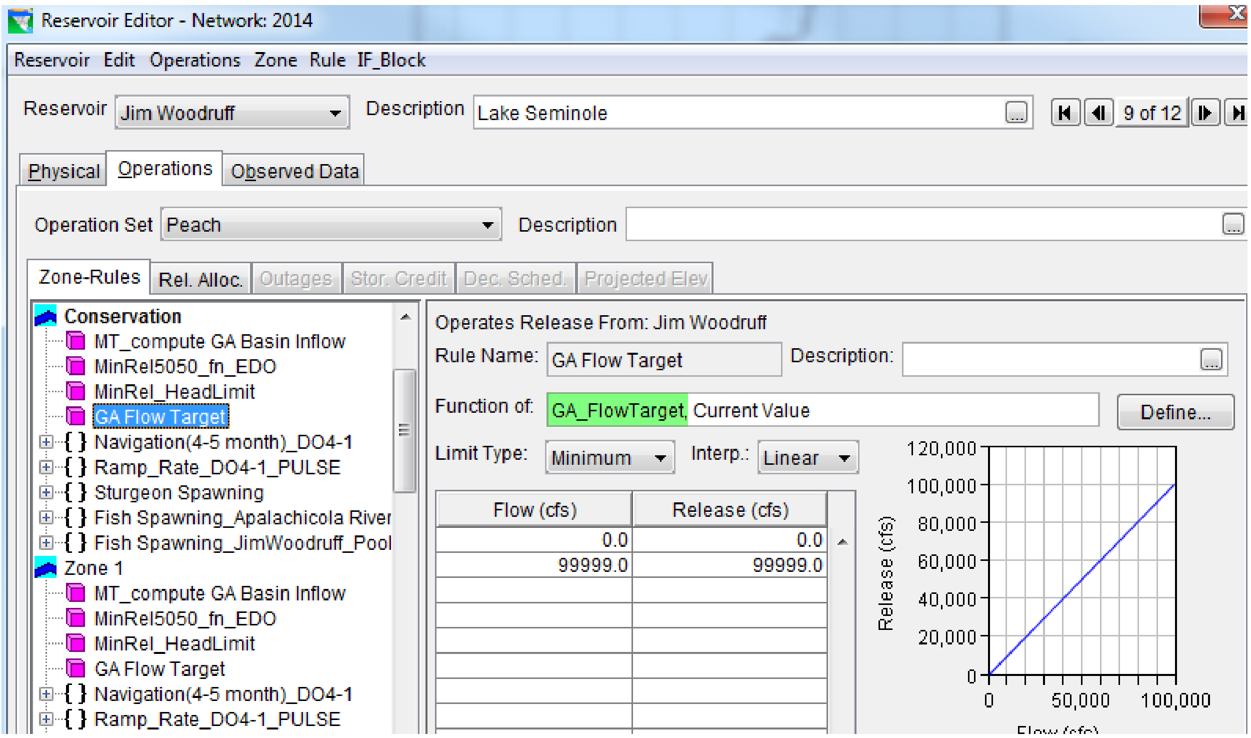


Figure H.13 Example of Applying State Variable “GA_FlowTarget”

11. FWS_FlowTarget

The operational requirements for FWS alternative is represented in Figure H.14. This state variable computes the FWS monthly release from Jim Woodruff Dam.
FWS Target Flows, Augmentation Limits, and Minimum Flows are represented in Table H.08, Table H.09 , and Table H.10 respectively.

If 7-day basin inflow exceeds the month/zone target, releases the target flow from Jim Woodruff dam. All basin inflow exceeding the target is available for storage, subject to flood control roles. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Jim Woodruff dam is the greater of a.) the month/zone minimum or b.) basin inflow plus the zone augmentation.

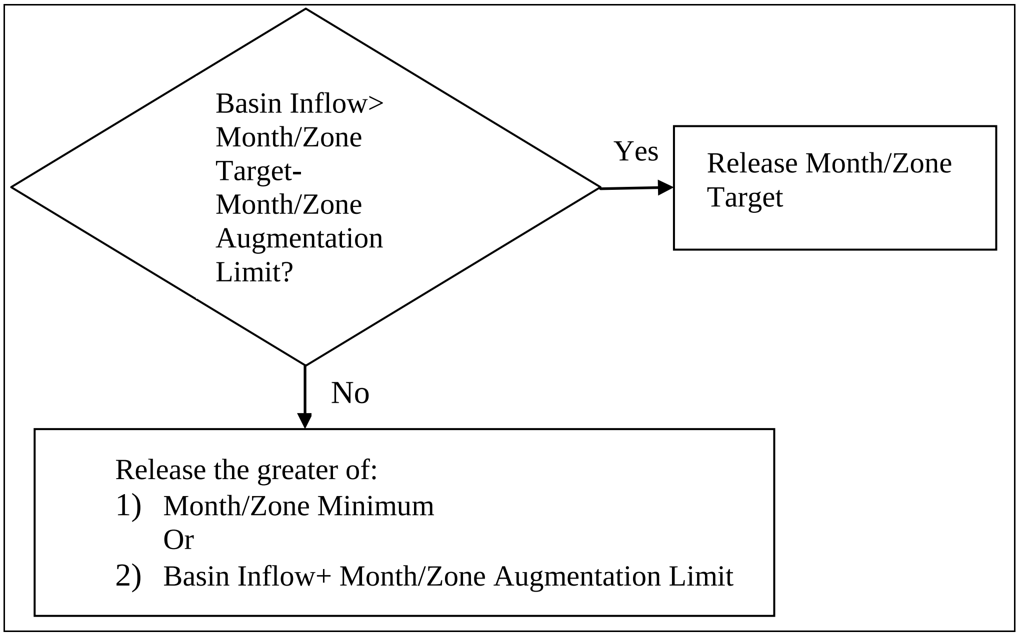


Figure H.14 Example of Applying State Variable FWS_FlowTarget

Table H.08 FWS Target Flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	19,000	17,000	10,000	5,000
Feb	21,000	19,000	10,000	5,000
Mar	21,000	19,000	14,000	5,000
Apr	21,000	19,000	14,000	5,000
May	19,000	17,000	10,000	5,000
Jun	14,000	14,000	10,000	5,000
Jul	12,000	10,000	10,000	5,000
Aug	12,000	10,000	10,000	5,000
Sep	10,000	10,000	10,000	5,000
Oct	10,000	10,000	10,000	5,000
Nov	10,000	10,000	10,000	5,000
Dec	10,000	10,000	10,000	5,000

Table H.09 FWS Augmentation Limits (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	2,000	0	1,000	0
Feb	4,000	2,000	2,000	0
Mar	4,000	2,000	3,000	0
Apr	4,000	2,000	3,000	0
May	2,000	4,000	2,000	0
Jun	2,000	2,000	1,000	0
Jul	2,000	2,000	1,000	0
Aug	2,000	2,000	1,000	0
Sep	0	1,500	1,000	0
Oct	0	1,500	1,000	0
Nov	0	1,500	1,000	0
Dec	0	1,500	1,000	0

Table H.10 FWS Minimum flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	17,000	17,000	5,000	5,000
Feb	17,000	17,000	5,000	5,000
Mar	17,000	17,000	8,000	5,000
Apr	17,000	17,000	8,000	5,000
May	17,000	10,000	8,000	5,000
Jun	12,000	8,000	5,000	5,000
Jul	10,000	7,000	5,000	5,000
Aug	10,000	7,000	5,000	5,000
Sep	10,000	6,000	5,000	5,000
Oct	10,000	5,000	5,000	5,000
Nov	10,000	6,000	5,000	5,000
Dec	10,000	8,000	5,000	5,000

Figure H.15 shows an example of application of "FWS_FlowTarget" state variable.

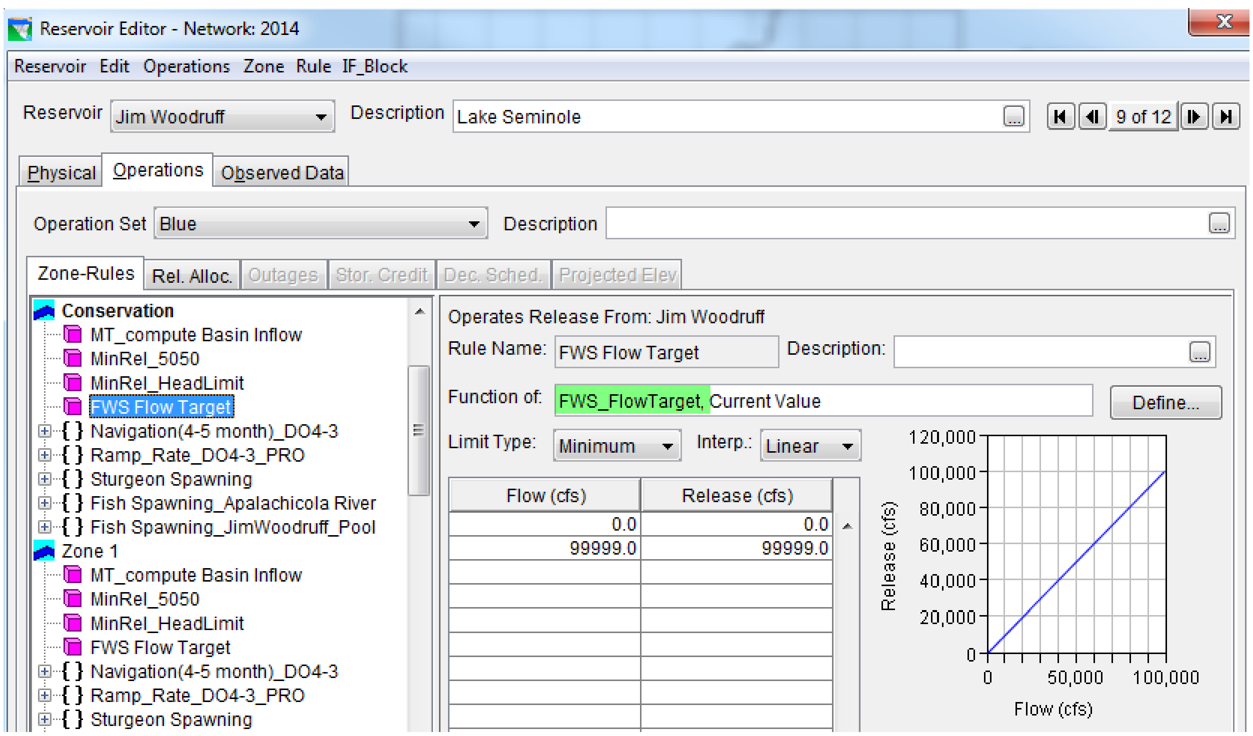


Figure H.15 Example of Applying State Variable "FWS_FlowTarget"

B. State Variables for Required Power and Energy Tracking

1. BufordActivePowerReq

This master state variable collects the computed power and energy requirements into a pair of slave state variables for each project. The required power and energy were identified as needed output by the PDT for alternative analysis.

ResSim computes the energy and power required separately for each power rule implemented in each zone, but only output for the currently active rule for each timestep is needed. This state variables determine the active power rule for each time step for each reservoir and and saves that rule's required power and energy values to the relevant state variable so that one dataset (the state variable) shows the power or energy requirement regardless of which zone the reservoir occupied.

All the work is done in BufordActivePowerReq, simply for the convenience of the script writing. It determines active power and active energy required for Buford, West Point, and Walter F. George. Since the information generated is not used to make release decisions, this master state variable is computed as a post-process (i.e., check "Compute as Post Process").

The script first sets up a list of zones and associated power rules for each project according to the following power guide curves (Source: "ACF_POWERGUIDECURVEDEF.xls"):

WF George and West Point

	hrs	Plant Factor	Rule Name	Rule Description
FC	4	16.67%	FC_4HrsGen	4 hours of generation at full capacity
Con	4	16.67%	Z1_4HrsGen	4 hours of generation at full capacity
Z2	2	8.33%	Z2_2HrsGen	2 hours of generation at full capacity
Z3	2	8.33%	Z3_2HrsGen	2 hours of generation at full capacity
Z4	0	0	(no rule)	

Note: West Point is same as WF George.

Buford

	hrs	Plant Factor	Rule Name	Rule Description
FC	3	12.50%	Z1_3HrsGen	3 hours of generation at full capacity
Con	3	12.50%	Z1_3HrsGen	3 hours of generation at full capacity
Z2	2	8.33%	Z2_2HrsGen	2 hours of generation at full capacity
Z3	2	8.33%	Z3_2HrsGen	2 hours of generation at full capacity
Z4	0	0	(no rule)	

For each project, the script then calls for the zone elevations at the current run time step and the pool elevation for the previous run time step. It determines in which zone the pool lies and then selects the corresponding power rule (or no power rule for certain zones) as the active rule. Finally the script stores the values of the required power and energy from the active rules to the following state variables:

- BufordActivePowerReg
- BufordActiveEnergyReg
- WestPointActivePowerReg
- WestPointActiveEnergyReg
- WalterFGeorgeActivePowerReg
- WalterFGeorgeActiveEnergyReg

C. State Variable Used for Gulf Sturgeon Spawning Operational Consideration

1. MinStage_Chattahoochee

The state variable, named "**MinStage_Chattahoochee**", describes the Corps' operation strategy for avoiding stranding Gulf sturgeon eggs and larvae when flows are declining from 40,000 cfs during the sturgeon spawning season from March through May. During a 2-week moving time window, when the releases from Jim Woodruff Dam are less than 40,000 cfs, the maximum drop from the Apalachicola River stage on the fourteenth day prior to the current day is 8 feet. Details of this operational strategy are described in a separate document (file name: 8footdrop.pdf).

The MinStage_Chattahoochee state variable determines the minimum stage on the Apalachicola River for the current day during the sturgeon spawning season. Using the stage-discharge rating curve on the Chattahoochee gage, a minimum flow release rule is established at Jim Woodruff Dam (Figure H.16).

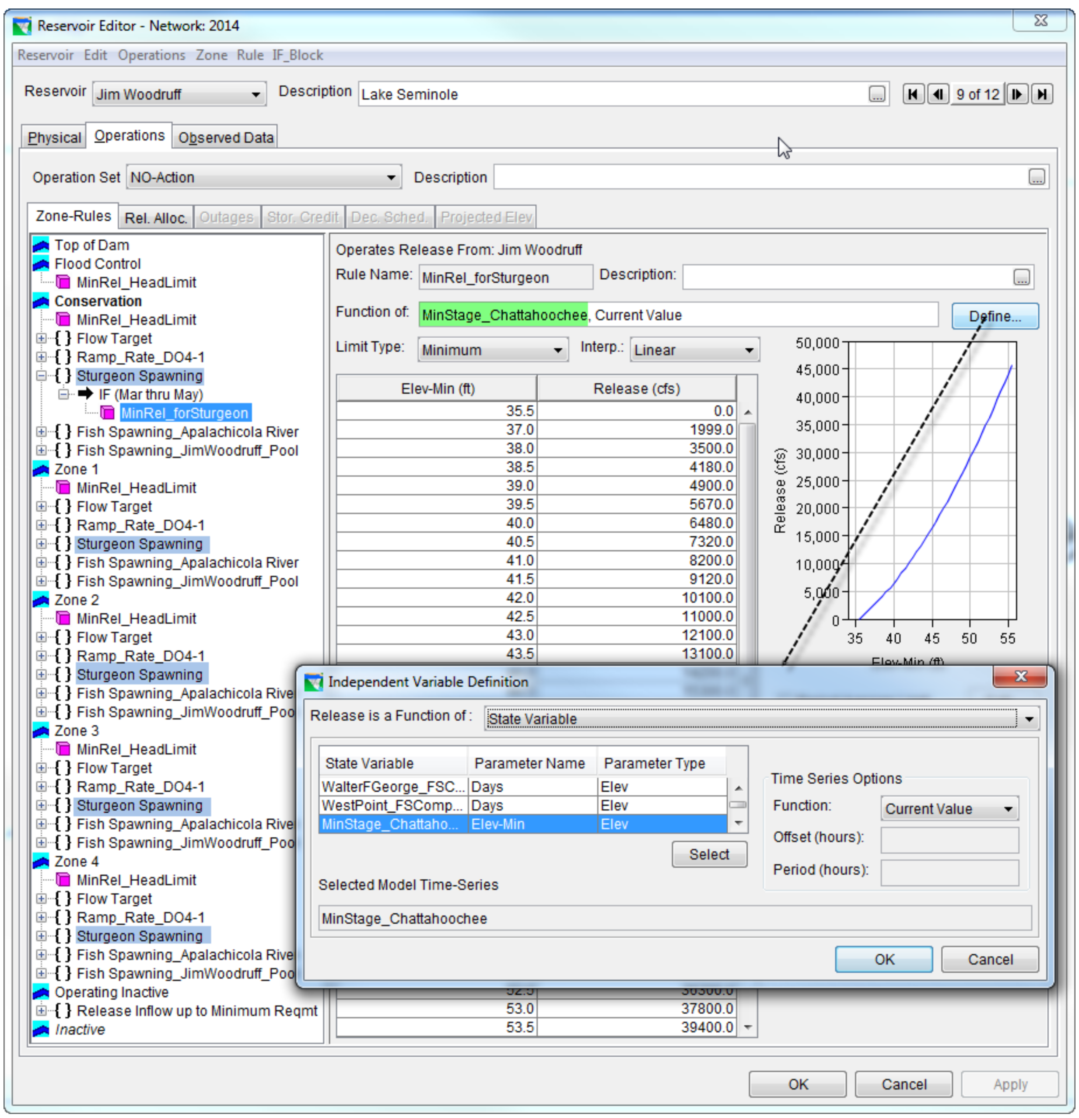


Figure H.16 Example of Applying State Variable "MinStage_Chattahoochee"

D. State Variables Used for Fish Spawning Operational Consideration

In accordance with the procedures of SAM standing operating procedure (SOP) SADR PDS-0-1, entitled "Programs Supports Division Lake Regulation and Coordination for Fish Management Purposes, Mobile District, Corps of Engineers, Department of the Army, May 2010," during the spawning periods, the Corps shall operate for generally stable or rising reservoir levels, and generally stable or gradually declining river stages on the Apalachicola River, for approximately 4 to 6 weeks during the designated spawning period for the specified project area (seeTable H.11). For more details, refer to a separate document, entitled "Implement SOP for Fish Management Purpose (Fish Spawning)_01242010.doc" on Groove at /ACF Alternative Information.

Table H.11 Fish Spawning Periods for Projects in the ACF Basin

Project/Water Body	Principal Fish Spawning Period for Operational Consideration
Buford (Lake Sidney Lanier)	01 April – 31 May
West Point Lake	01 April – 31 May
Walter F. George Lake	15 March – 15 May
Jim Woodruff (Lake Seminole)	15 March – 15 May
Jim Woodruff (Apalachicola River)	01 April – 31 May

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.

1. *Buford_Elev_State, WestPoint_Elev_State, WalterFGeorge_Elev_State, and JimWoodruff_Elev_State*

These master state variables determine the base elevation and elevation state for each project. 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: Buford_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

```

As an example, the script that calculates the elevation drop and assigns a code value to the Buford_Elev_State state variable is shown as follows:

```
	LL_ELEV_TS = network.getTimeSeries("Reservoir","Buford", "Pool", "Elev")
	LL_ELEV = LL_ELEV_TS.getPreviousValue(currentRuntimestep)
	BaseELEV_StVar=network.getStateVariable("Buford_BaseElev")
	BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)

	if BaseELEV_Pre < LL_ELEV:
		# Pool is rising, reset BaseELEV
		BaseELEV_Cur=LL_ELEV
		Code=0

	else :
		# Pool is steady or falling
		BaseELEV_Cur=BaseELEV_Pre

		Diff=BaseELEV_Pre - LL_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
```

Depending on the amount of lake elevation drop from the base elevation, represented by the Elev_State state variable, a maximum draw-down limit is specified for the current time step such that the total elevation drop from the base elevation is limited to 6 inches. For example, if the current lake elevation state is 2, meaning that the lake elevation drop from the base elevation up to the previous day is equal to or less than 0.3 foot, the maximum lake elevation drop allowed for the current day is 0.2 foot (Figure H.17—inset). Figure H.17shows how the Buford_Elev_State state variable is used to specify the maximum elevation rate of change limit rules.

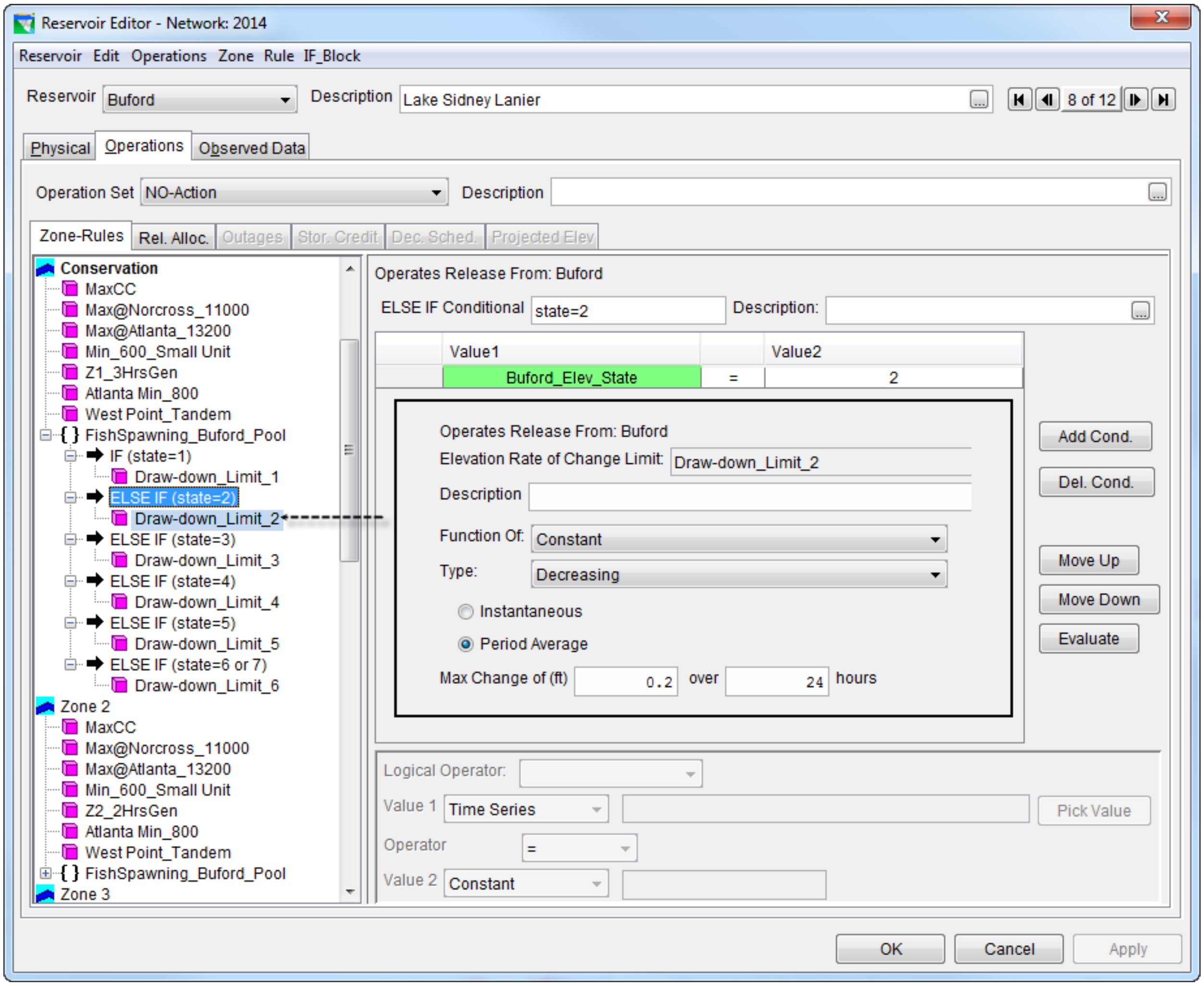


Figure H.17 Example of Applying State Variable "Buford_Elev_State"

2. ***Buford_BaseElev, WestPoint_BaseElev, WalterFGeorge_BaseElev, and JimWoodruff_BaseElev***

   These (slave) state variables hold each lake's base elevation used in managing lake level rising/falling during the fish spawning periods for Lake Sidney Lanier, West Point Lake, Walter F George Lake, and Lake Seminole. For each lake, 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.

3. ***Buford_FSCompliance, WestPoint_FSCompliance, WalterFGeorge_FSCompliance, and JimWoodruff_FSCompliance***

   These (slave) state variables contain the numbers of days during the fish spawning periods that the fish spawning requirements are met. The counts increase by one if the cumulative pool elevation drop from the base elevation is not greater than 6 inches.

E. State Variables Used for Navigation

1. NavigationSeason

This state variable specifies the time window for navigation seasons, which are from January through May. The script itself is simple (Figure H.18). It returns a value of 1 for the navigation season and 2 for non-navigation season to the NavigationSeason state variable.

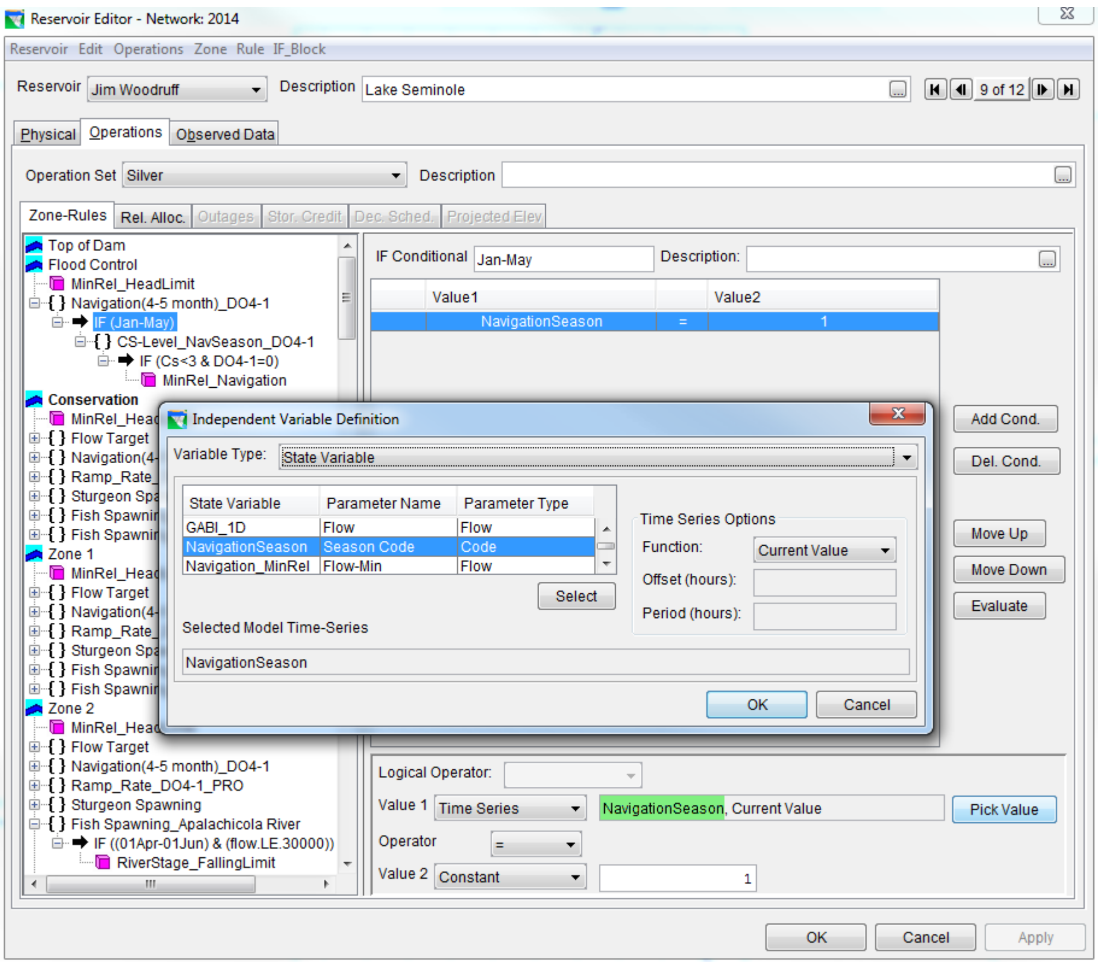


Figure H.18 Example of Applying State Variable "NavigationSeason"

During the Navigation season, when the composite storage is in Zone 1 or Zone 2, and when Jim Woodruff does not operate for drought, Jim Woodruff operates for navigation along the Apalachicola River. The navigation requirement is to meet a minimum flow of 16,200 cfs at Blountstown (located downstream of Jim Woodruff as shown in Figure H.19). A minimum release rule *MinRel_Navigation* initiates the release of all incoming flow to maintain flow rate of 16,200 cfs at Blountstown to provide 7 ft of navigation depth.

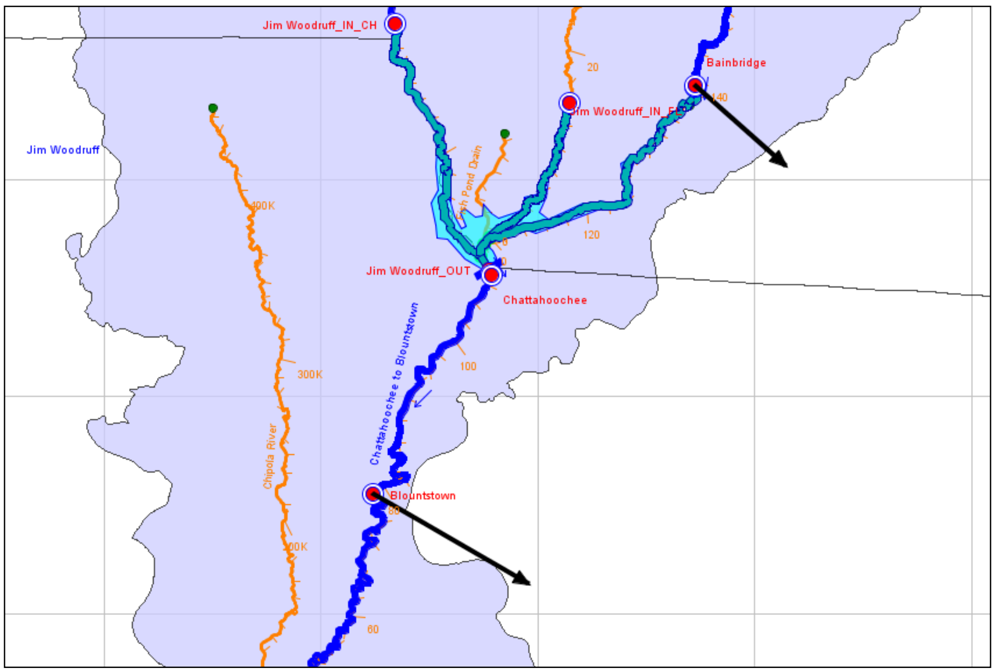


Figure H.19 Location of Blountstown Downstream of Jim Woodruff

2. BI_TriRivers_Calc and NavQ_BI_TriRivers_Calc

The Tri-Rivers Navigation rule proposed by Alabama establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table H.12.

The “BI_TriRivers_Calc” state variable is used to calculate the release for navigation from Jim Woodruff during March through May , when composite storage is in zone 1 and Basin Inflow is greater than the greater of 16,000 cfs and 9ft Navigation minus 9ft Augmentation (which is equal to 15,800) .In this condition the release from Jim Woodruff is the greater of either the sum of 16,000 cfs and 50% of the basin inflow greater than 16,000 cfs or the 9 ft navigation flow requirement which is 18,800 cfs.

The “NavQ_BI_TriRivers_Calc” computes the release for navigation from Jim Woodruff during March through May, when composite storage is in zone 2 and Basin Inflow is greater than the greater of 16,000 cfs and 9ft Navigation minus 9ft Augmentation (which is equal to 15,800) .In this condition the release from Jim Woodruff is the greater of either the sum of 16,000 cfs and 50% of the basin inflow greater than 16,000 cfs or thesum of 9 ft navigation flow requirement and 50% of the basin inflow greater than 9 ft navigation flow requirement.

Table H.12 Tri-Rivers Navigation Rule from Jim Woodruff Dam

Months	Composite Storage Zone	Basin Inflow(BI)(cfs)	Release from JWLD(cfs)
Mar-May	Zone 1	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 2	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ+50%BI>9 ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 3	>=39,000	=25,000
		>=9ft NavQ-9ft Augmentation	= 9 ft NavQ+50%BI>9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
Jun-Nov	Zones 1,2, and 3	>=22,000	=max(16,000;9ft NavQ)
		>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=10,000 and <7ft NavQ- 7ft Augmentation	=10,000 + 50% BI>10,000
		>=5,000 and <10,000	=BI
		<5,000	=5,000
Dec-Feb	Zones 1,2, and 3	>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		<7ft NavQ- 7ft Augmentation	=5,000
At all times	Zone 4	NA	=5,000(Store all BI>5,000)
At all times	Corps Exceptional Drought Trigger Zone	NA	=4,500(Store all BI>4,500)*
*Once composite storage falls below the top of the Corps Exceptional Drought Trigger Zone ramp down			

F. State Variables Used for Describing Physical Constraints at Jim Woodruff , Walter F. George

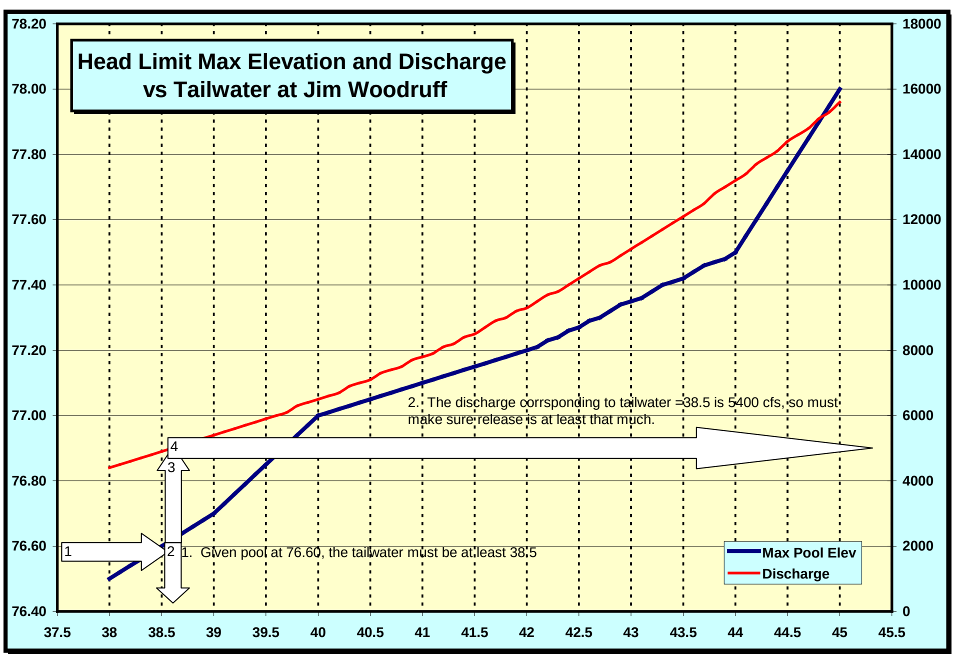
1. JimWoodruff_MinTailwater

This state variable determines the minimum tailwater elevation needed at Jim Woodruff Dam based on the dam's maximum head limit curve determined for dam structure stability. The curve was provided by SAM, in a spreadsheet, named "Headlimits_updatedForChattahooche.xls".

The script first defines the following lookup table to define the head limit curve, defining the minimum tailwater elevation necessary to adequately limit the head difference for a given reservoir pool elevation:

```
MaxPoolElev= [
[75.5,76.50,76.52,76.54,76.56,76.58,76.60,76.62,76.64,76.66,76.68,76.70,76.73,76.76,76.79,76.82,76.85,76.88,76.91,76.94,76.97,
 77.00,77.01,77.02,77.03,77.04,77.05,77.06,77.07,77.08,77.09,77.10,77.11,77.12,77.13,77.14,77.15,77.16,77.17,77.18,77.19,
 77.20,77.21,77.23,77.24,77.26,77.27,77.29,77.30,77.32,77.34,77.35,77.36,77.38,77.40,77.41,77.42,77.44,77.46,77.47,77.48,
 77.50,77.55,77.60,77.65,77.70,77.75,77.80,77.85,77.90,77.95,78.00],
[37.5,38., 38.1, 38.2, 38.3, 38.4, 38.5, 38.6, 38.7, 38.8, 38.9, 39., 39.1, 39.2, 39.3, 39.4, 39.5, 39.6, 39.7, 39.8, 39.9,
 40., 40.1, 40.2, 40.3, 40.4, 40.5, 40.6, 40.7, 40.8, 40.9, 41., 41.1, 41.2, 41.3, 41.4, 41.5, 41.6, 41.7, 41.8, 41.9,
 42., 42.1, 42.2, 42.3, 42.4, 42.5, 42.6, 42.7, 42.8, 42.9,43., 43.1, 43.2, 43.3, 43.4, 43.5, 43.6, 43.7, 43.8, 43.9,
 44., 44.1, 44.2, 44.3, 44.4, 44.5, 44.6, 44.7, 44.8, 44.9,45.]
]
```

The above table is shown as the lower curve on the following chart from the head limit spreadsheet:



The script then defines a linear interpolation function. Based on the pool elevation at the end of the previous time step, it determines the required minimum tailwater elevation, and saves the value to state variable.

A high priority minimum release rule, MinRel_Headlimit, is defined at Jim Woodruff as a function of this state variable. The state variable returns to the rule the minimum required tailwater elevation and the rule uses that value to determine the minimum release from the tailwater stage-discharge rating curve (dated

20Feb2008 at the downstream USGS Chattahoochee gage) specified in the rule - the upper (red) curve in chart above. The MinRel_HeadLimit rule is illustrated in Figure H.20.

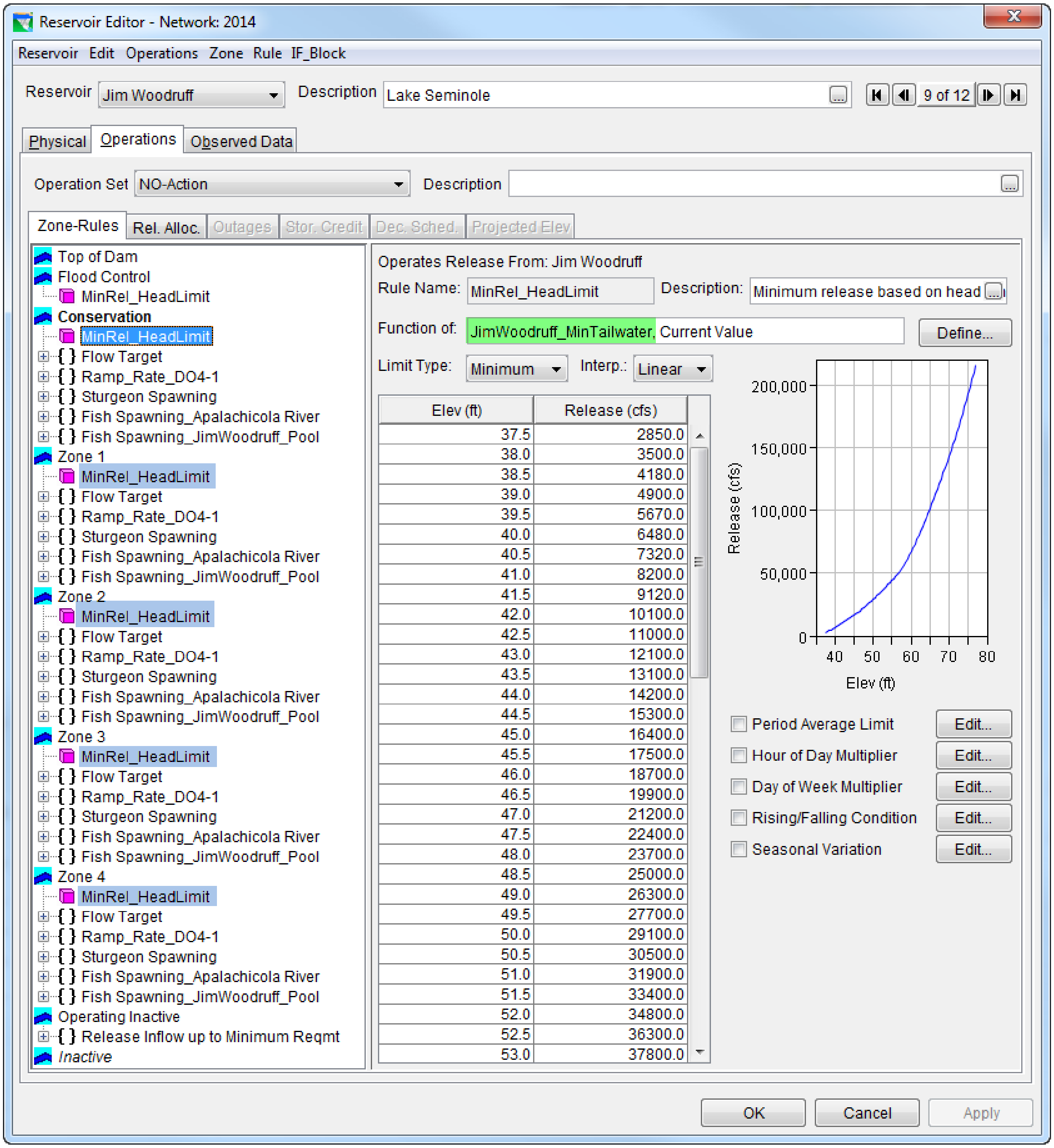


Figure H.20 Example of Applying State Variable "JimWoodruff_MinTailwater"

2. *WalterFGeorge_MinTailwater*

This state variable determines the minimum tailwater elevation needed at Walter F George dam based on the maximum head limit of 88 feet to retain structural stability of the dam. Based on the pool elevation at the previous time step, the script computes the minimum tailwater elevation. A high priority minimum release rule, MinFlow_Headlimits, is defined at Walter F George reservoir as a function of this state variable. The rule uses the tailwater value returned by the state variable to lookup the required discharge value in the stage-discharge rating curve entered as the "function" in the rule (Figure H.21).

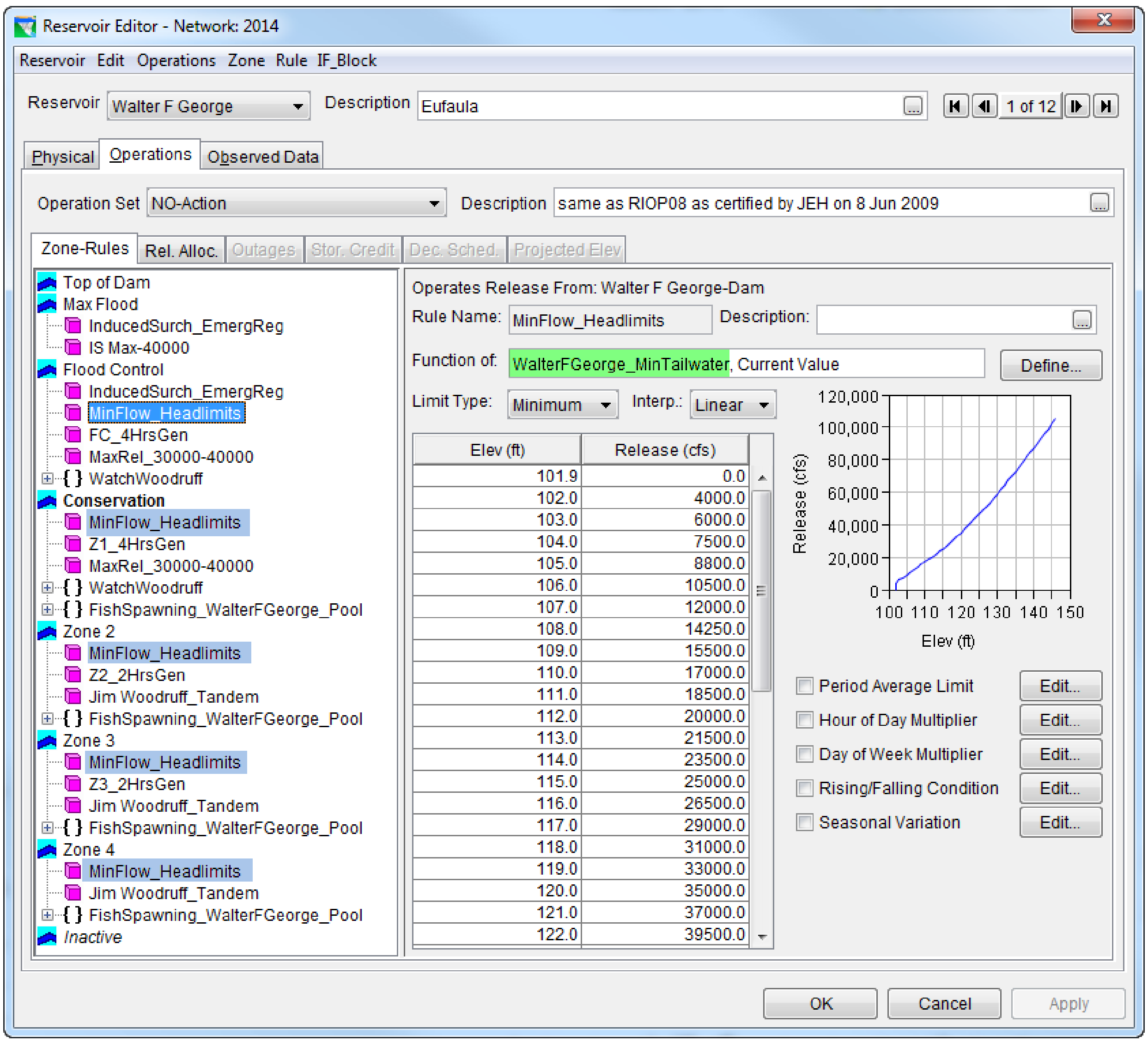


Figure H.21 Example of Applying State Variable "WalterFGeorge_MinTailwater"

G. Other State Variables

1. WestPoint_GCBuffer

The state variable, named "WestPoint_GCBuffer", defines a buffer zone around the West Point guide curve in which tandem operation is turned off in order to avoid oscillations of the results. As shown in Figure H.22, the state variable script determines if the pool elevation at the end of the previous time step is within a "buffer" range of the guide curve, which is defined as:

- When guide curve is rising, +/- 0.05' around the guide curve
- When guide curve is flat, +/- 0.05' around the guide curve
- When guide curve is falling, no buffer

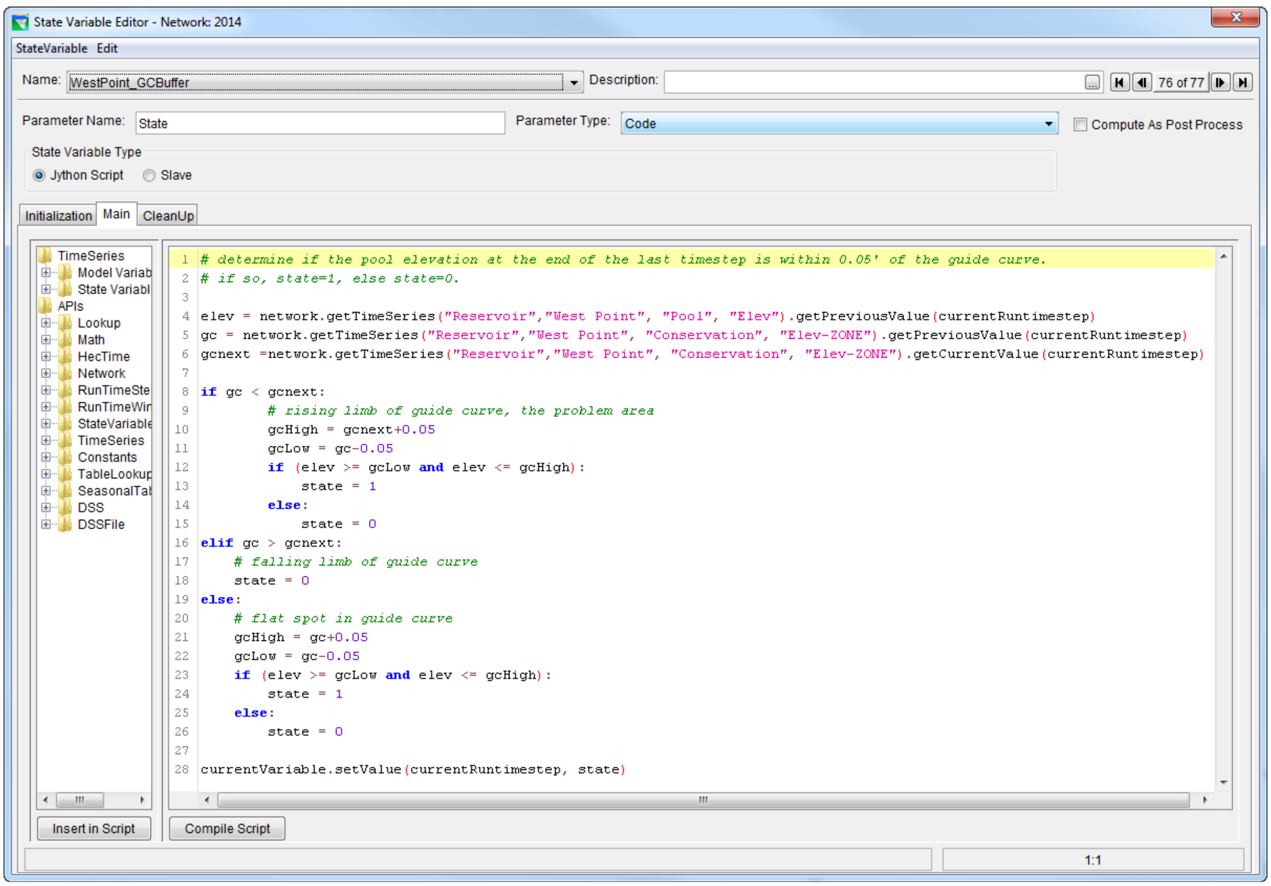


Figure H.22 Main Script for the State Variable "WestPoint_GCBuffer"

After much testing, it was found that the problem of the oscillations appeared when the pool at West Point is in the West Point guide curve buffer zone and when the pool at Walter F George is at or above the Walter F George guide curve. Therefore, an IF-Block is created to define these two conditions, under which tandem operation is turned off. Instead, the release is limited to the net inflow to West Point Lake up to the downstream channel capacity (Figure H.23).

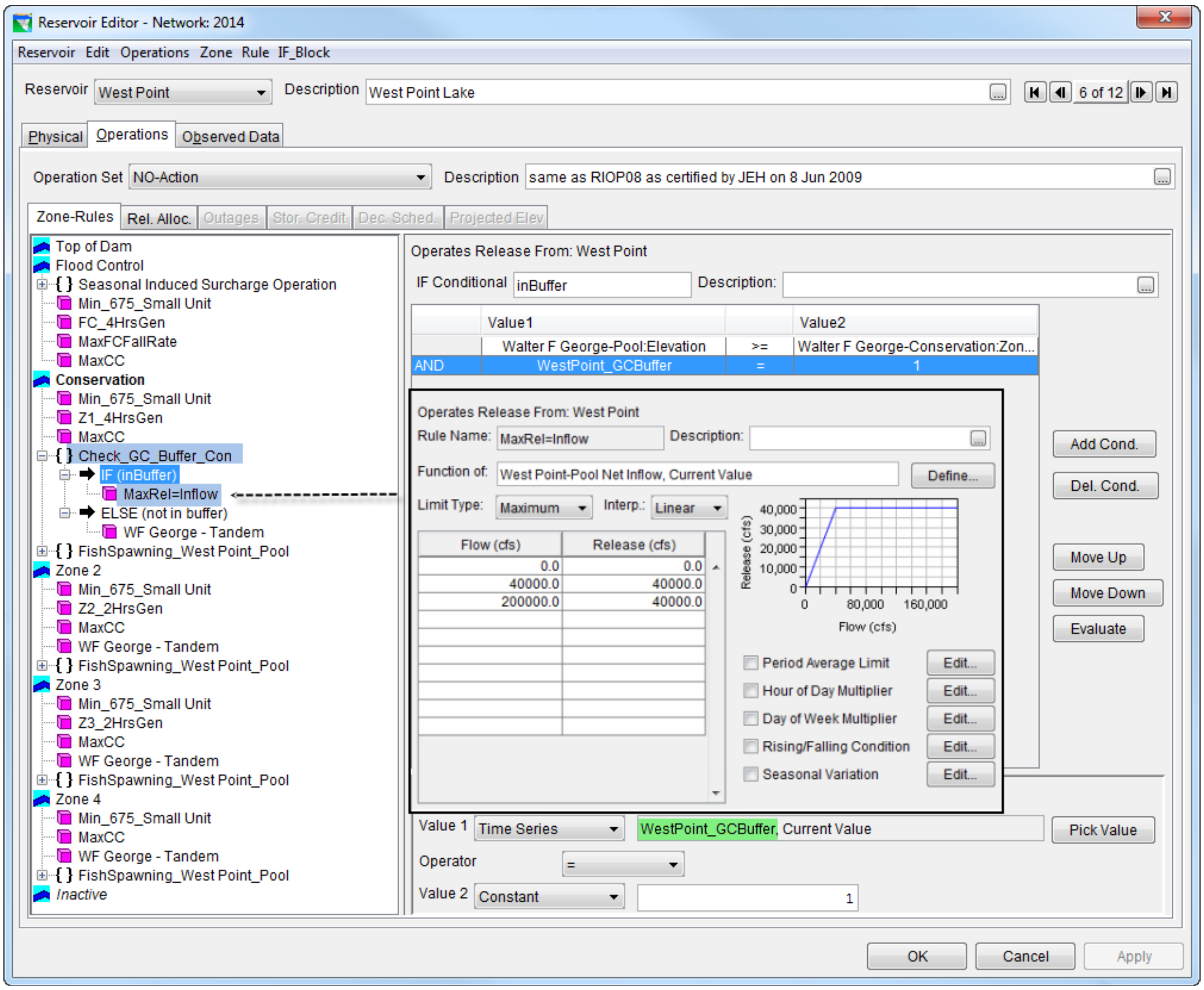


Figure H.23 Example of Applying State Variable "WestPoint_GCBuffer" and Model Variable "West Point-Pool Net Inflow"

2. FloodSeasons

The state variable, named "FloodSeasons", contains a code to identifying the current season, summer or winter, for each timestep. This state variable is used to select the appropriate induced surcharge rule for West Point Dam. As shown inFigure H.24, the state variable script defines April 15 through November 19 as summer and the rest of a year as winter.

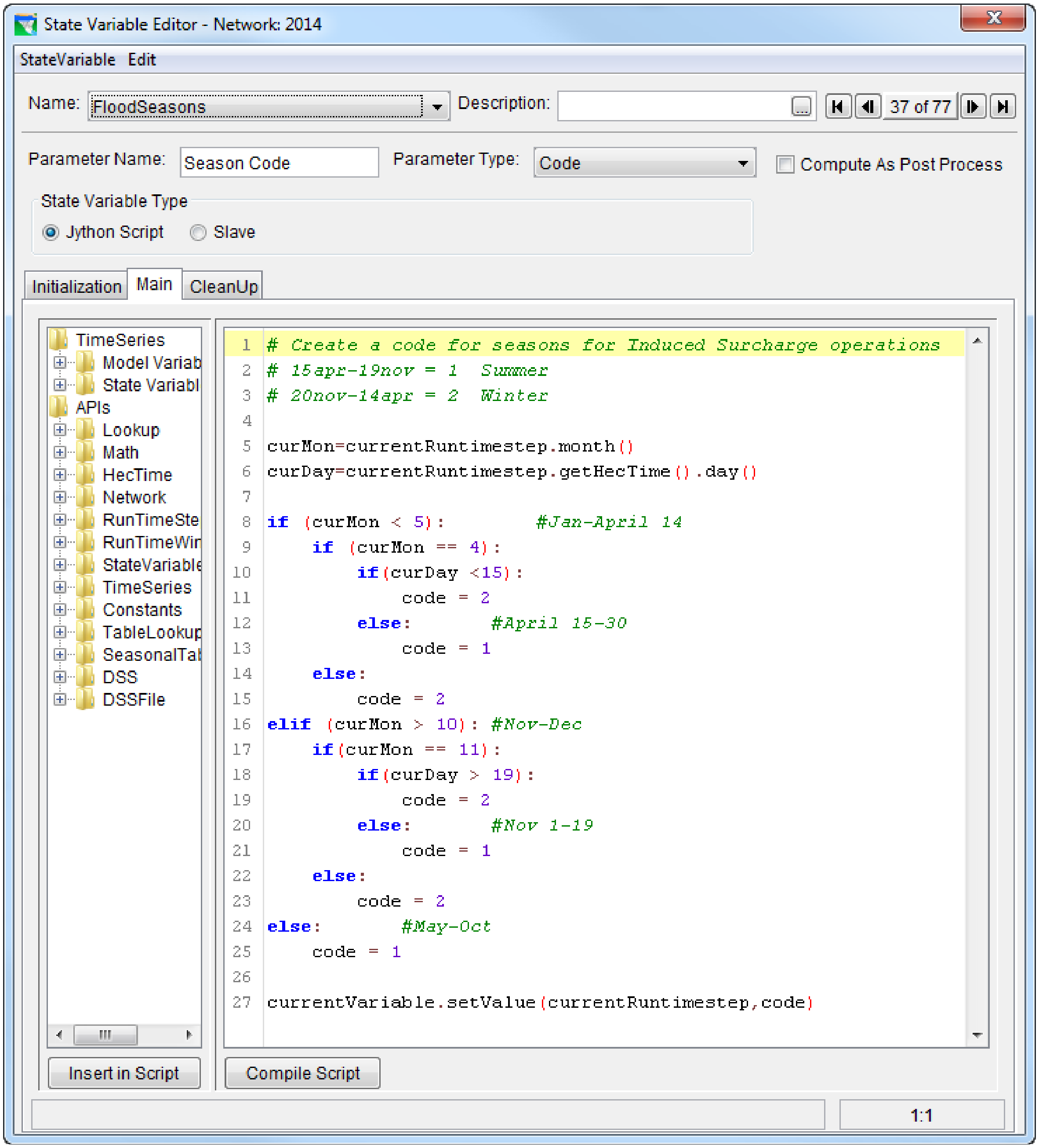


Figure H.24 Main Script for the State Variable "FloodSeasons"

Depending on the value of the "FloodSeasons" state variable, different induced surcharge operation rules are applied as shown inFigure H.25.

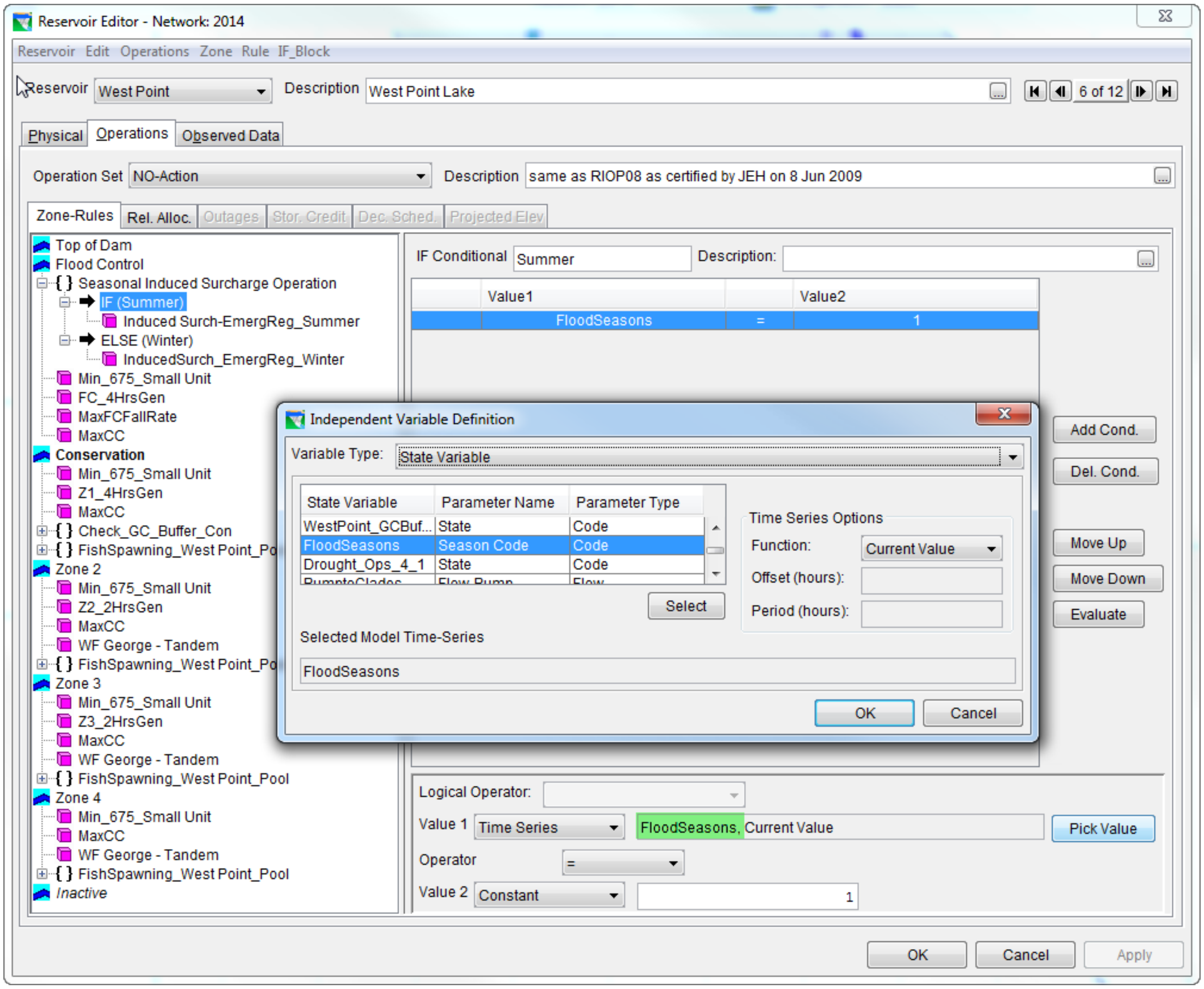


Figure H.25 Using the State Variable "FloodSeasons" at West Point

H. State Variables used for Pumping Operations for the Proposed Water Supply Reservoirs

1. Pump to Glades

Chattahoochee River Pump Station will pump to Glades Reservoir when flow rate in the River just upstream of the pump station exceeds the annual 7Q10 (183.5 cfs), and when water level in Glades Reservoir is lower than 1180 ft MSL. When flow rate in the Chattahoochee River is equal to or less than the annual 7Q10, the pump station will not operate, even if Glades Reservoir's water level is lower than 1,180 ft MSL.

2. Pump to Bear

The Bear Creek Pump station will divert water from the Chattahoochee River just upstream of the confluence with Bear Creek to Bear Creek reservoir. Diversions are assumed to occur whenever the reservoir level fell below 80% of full reservoir storage (EL 750.7906) as long as adequate flow exists in the Chattahoochee. If the reservoir is below 80% of full storage at the end of the day (without diversion pumping), the lesser of the following volumes was computed and delivered to the reservoir:

- The amount of pumping needed to refill the reservoir to 80% capacity
- The designated diversion pumping capacity (21.5 cfs)
- The diversion volume that can be accommodated considering Low Flow Requirements in the Chattahoochee River

III. Contents of State Variable Scripts

Scripts for the Master State Variables used for

A. Revised Interim Operations Plan at Jim Woodruff

- CompositeStorage
- Drought_Ops_4_1
- Drought_Ops_4_3
- Drought_Ops_3_1
- ProlongedLowFlow
- Seasons
- BIFallRate
- BI_FMA7
- FLBI_FMA7
- GABI_FMA7
- FL_FlowTarget
- GA_FlowTarget
- FWS_FlowTarget

CompositeStorage

This is a master state variable that determines the values for the following slave state variables:

CS_ACT: Actual composite storage
CS_TOD: Composite storage at top of dam zone
CS_FC: Composite storage at top of flood control zone
CS_CON: Composite storage at top of conservation zone (top of Zone 1)
CS_Z2: Composite storage at top of Zone 2
CS_Z3: Composite storage at top of Zone 3
CS_Z4: Composite storage at top of Zone 4
CS_EDT: Composite storage at top of the EDT zone
CS_IA: Composite storage at top of inactive zone

```
#####
##### 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))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	leapYears =  [ 1900,1904,1908,1912,1916,1920,1924,1928,1932,1936,1940,1944,1948,1952,1956,1960,
	1964,1968,1972,1976,1980,1984,1988,1992,1996,2000,2004,2008,2012,2016,2020,2024,2028,2032,2036,
	2040,2044,2048,2052,2056,2060,2064,2068,2072,2076,2080,2084,2088,2092,2096,2100,2104,2108,2112,
	2116,2120,2124,2128,2132,2136,2140,2144,2148,2152,2156,2160,2164,2168,2172,2176,2180,2184,2188,
	2192,2196,2200,2204,2208,2212,2216,2220,2224,2228,2232,2236,2240,2244,2248,2252,2256,2260,2264,
	2268,2272,2276,2280,2284,2288,2292,2296,2300 ]

	currentVariable.varPut("leapYears", leapYears)

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	#01Jan is day 1 in both leap and non-leap years
	#01Apr is day 91  in non-leap years and day 92  in leap years
	#01Jul is day 182 in non-leap years and day 183 in leap years
	#01Nov is day 305 in non-leap years and day 306 in leap years
	#04Dec is day 338 in non-leap years and day 339 in leap years
	#31Dec is day 365 in non-leap years and day 366 in leap years

	# Main inflection points that define the Exceptional Drought Trigger (EDT) curve
	# commented out lines reflect total composite storage
	# per JEH 9/26/2008...
	#      useable storage reflects subtraction of Inactive storage = 1,856,550 ac-ft
	EDT_nl_yr = [[1,91,182,305,338,365],
	#[ 495458,  864946, 864946,  621618,  530050,  497830] ]
	[2352008,2721496,2721496,2478168,2386600,2354380] ]
	EDT_l_yr =[ [1,92,183,306,339,366],
	#[ 495458,  864946, 864946,  621618,  530050,  497830] ]
	[2352008,2721496,2721496,2478168,2386600,2354380] ]

	currentVariable.varPut("EDT_nlyr", EDT_nl_yr)
	currentVariable.varPut("EDT_lyr", EDT_l_yr)
```

```
#		- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 	# 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
#from hec.hecmath import DSS
#from hec.model import Interpolate
from hec.heclib.util import intContainer

# This state variable, called "CompositeStorage", determines in which
# Composite Storage Zone lies the Actual Composite Storage of the
# three-reservoir system (S. Lanier, W. Point, W.F. George)
# modified by Joan (Oct 2009, for speed and program enhancements)

# 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

# ------------------------------------------------------------------------------------------------------------------------
# Define Linear Interpolation and Lookup Functions
# ------------------------------------------------------------------------------------------------------------------------

# Linear Interpolation Function
def interpolate(x, x0, x1, y0, y1):
	y = y0 + (x - x0) * ( (y1-y0) / (x1-x0) )
	return y

# Lookup Function
def lookup(table, lookupVar):
	debugLevel = 1
	tabLen = len(table[0])
	if  table[0][0] >= lookupVar :
		# return first value
		returnVar = table[1][0]
		if table[0][0] > lookupVar and debugLevel == 6 :
			message = "CompositeStorage SV" + currentRuntimestep.dateTimeString() + "lookup elevation is
outside table limits; return value assumed to be the first value in the table"
			network.printLogMessage(message)
	elif table[0][-1] <= lookupVar:
		# return last value
		returnVar = table[1][-1]
		if table[0][-1] > lookupVar and debugLevel == 6 :
			message = "CompositeStorage SV" + currentRuntimestep.dateTimeString() + "lookup elevation is
outside table limits; return value assumed to be the last value in the table"
			network.printLogMessage(message)
	else:
		# lookupVar IS in the table, find the index of the first table value greater than lookupVar using a binary search

		lo = 0
		hi = tabLen-1
		while hi - lo > 1 :
			mid = (lo + hi) / 2
			if table[0][mid] > lookupVar :
				hi = mid
			else :
				lo = mid
		# now that we know where to look, interpolate for the return value (if necessary)
		if table[0][hi-1] == lookupVar :
			returnVar = table[1][hi-1]
		else:
			returnVar = interpolate(lookupVar, table[0][hi-1], table[0][hi], table[1][hi-1], table[1][hi])

	return returnVar
# ------------------------------------------------------------------------------------------------------------------------
#
#    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

#	print "performing composite storage calculation for step ", current_step, "  ", currentRuntimestep.dateTimeString()," PASS=",network.getComputePassCounter()

# Current storage each reservoir (Sidney Lanier, West Point, and Walter F. George)
	SL_STOR = network.getTimeSeries("Reservoir","Buford", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	WP_STOR = network.getTimeSeries("Reservoir","West Point", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	WG_STOR = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	CS_Actual = SL_STOR + WP_STOR + WG_STOR

# Buford  (Lake Sidney Lanier) zone storages
	SL_TOD = network.getTimeSeries("Reservoir","Buford", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_FC = network.getTimeSeries("Reservoir","Buford", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_CON = network.getTimeSeries("Reservoir","Buford", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z2 = network.getTimeSeries("Reservoir","Buford", "Zone 2", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z3 = network.getTimeSeries("Reservoir","Buford", "Zone 3", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z4 = network.getTimeSeries("Reservoir","Buford", "Zone 4", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_IA = network.getTimeSeries("Reservoir","Buford", "Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)

# West Point  zone storages
	WP_TOD = network.getTimeSeries("Reservoir","West Point", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_FC = network.getTimeSeries("Reservoir","West Point", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_CON = network.getTimeSeries("Reservoir","West Point", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z2 = network.getTimeSeries("Reservoir","West Point", "Zone 2", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z3 = network.getTimeSeries("Reservoir","West Point", "Zone 3", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z4 = network.getTimeSeries("Reservoir","West Point", "Zone 4", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_IA = network.getTimeSeries("Reservoir","West Point", "Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)

# Walter F. George zone storages
	WG_TOD = network.getTimeSeries("Reservoir","Walter F George", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_FC = network.getTimeSeries("Reservoir","Walter F George", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_CON = network.getTimeSeries("Reservoir","Walter F George", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z2 = network.getTimeSeries("Reservoir","Walter F George", "Zone 2", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z3 = network.getTimeSeries("Reservoir","Walter F George", "Zone 3", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z4 = network.getTimeSeries("Reservoir","Walter F George", "Zone 4", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_IA = network.getTimeSeries("Reservoir","Walter F George", "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
# ---------------------------------------------------------------------------------------------------------------------

# Current composite storage
	CS_Actual = SL_STOR + WP_STOR + WG_STOR
	network.getStateVariable("CS_ACT").setValue(currentRuntimestep, CS_Actual)
```

```
# Storage at Top of Dam zone
        CS_TOD = SL_TOD + WP_TOD + WG_TOD
        network.getStateVariable("CS_TOD").setValue(currentRuntimestep, CS_TOD)

# Storage at top of Flood Control zone
        CS_FC = SL_FC + WP_FC + WG_FC
        network.getStateVariable("CS_FC").setValue(currentRuntimestep, CS_FC)

# Storage at top of Conservation zone (top of Zone 1)
        CS_CON = SL_CON + WP_CON + WG_CON
        network.getStateVariable("CS_CON").setValue(currentRuntimestep, CS_CON)

# Storage at top of Zone 2
        CS_Z2 = SL_Z2 + WP_Z2 + WG_Z2
        network.getStateVariable("CS_Z2").setValue(currentRuntimestep, CS_Z2)

# Storage at top of Zone 3
        CS_Z3 = SL_Z3 + WP_Z3 + WG_Z3
        network.getStateVariable("CS_Z3").setValue(currentRuntimestep, CS_Z3)

# Storage at top of Zone 4
        CS_Z4 = SL_Z4 + WP_Z4 + WG_Z4
        network.getStateVariable("CS_Z4").setValue(currentRuntimestep, CS_Z4)

# Storage at top of Inactive zone
        CS_IA = SL_IA + WP_IA + WG_IA
        network.getStateVariable("CS_IA").setValue(currentRuntimestep, CS_IA)

# Storage at top of Exceptional Drought Trigger (EDT) Zone

        leapYears = currentVariable.varGet("leapYears")
        EDT_nl_yr = currentVariable.varGet("EDT_nlyr")
        EDT_l_yr = currentVariable.varGet("EDT_lyr")

        day = currentRuntimestep.getHecTime().dayOfYear()
        year = currentRuntimestep.getHecTime().year()
        if year in leapYears:
                EDT_table = EDT_l_yr
        else:
                EDT_table = EDT_nl_yr

        CS_EDT = lookup(EDT_table,day)
        network.getStateVariable("CS_EDT").setValue(currentRuntimestep, CS_EDT)

# -----------------------------------------------------------------------------------------------------------------------
# Check 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            State
#        ----------   ----------
#        Above Con.      0
#        Zone 1(Con)     1
#        Zone 2          2
#        Zone 3          3
#        Zone 4          4
#        EDT             5
#
        if CS_Actual > CS_CON :
                CS_state = 0
        elif  CS_Actual > CS_Z2 :
                CS_state = 1
        elif  CS_Actual > CS_Z3 :
                CS_state = 2
        elif  CS_Actual > CS_Z4 :
                CS_state = 3
        elif  CS_Actual > CS_EDT :
                CS_state = 4
        else :
                CS_state = 5
```

```
        currentVariable.setValue(currentRuntimestep, CS_state)
#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# 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()
```

Drought_Ops_4_1

```
#####
##### 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 state variable, called "Drought_Ops_4_1", determines
# at the beginning of every month whether or not the system's
# Composite Storage is within the drought zones, Zone 4 or
# the Exceptional Drought Trigger zone.Also it defines a new State
# variable named "Hold_RR" which triggers RIOP falling Ramp Rate when Drought
#is occured and it hold the Ramp Rate till the drought is suspended or flow 4550 (EDO)
# or 5050(Not EDO) is reached.

# 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

from hec.script import Constants

#Buffer is a parameter to adjust the trigger for resuming RR after a temporarily suspension (unit=cfs)
Buffer=200
# ------------------------------------------------------------------------------------------------------------------------
# Read input state variable time series & value @ current run time step
# ------------------------------------------------------------------------------------------------------------------------

CS_state = network.getStateVariable("CompositeStorage").getValue(currentRuntimestep)

JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
JWD_Q_prev=JWD_Q_TS.getPreviousValue(currentRuntimestep)
JWD_Q_prev2=JWD_Q_TS.getLaggedValue(currentRuntimestep, 2)

#message =  "\n\n\n" + currentRuntimestep.dateTimeString() + "\tCompositeStorage " + `CS_state`
#network.printLogMessage(message)

DOps_state_prev = currentVariable.getPreviousValue(currentRuntimestep)

EDOflowSV = network.getStateVariable("EDO_Flow")
EDOflow_prev = EDOflowSV.getPreviousValue(currentRuntimestep)

Hold_RR_SV = network.getStateVariable("Hold_RR")
Hold_RR_prev = Hold_RR_SV.getPreviousValue(currentRuntimestep)

Min_Reached_SV=network.getStateVariable("Min_Reached")
Min_Reached_prev=Min_Reached_SV.getPreviousValue(currentRuntimestep)

# ------------------------------------------------------------------------------------------------------------------------
# Check the Composite Storage State at the Beginning of every month
# ------------------------------------------------------------------------------------------------------------------------

mon = currentRuntimestep.getHecTime().month()
day = currentRuntimestep.getHecTime().day()
hour = currentRuntimestep.getHecTime().hour()
```

```
#message =  currentRuntimestep.dateTimeString() + "\tmon " + `mon`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\tday " + `day`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\thour " + `hour`
#network.printLogMessage(message)

from hec.model import RunTimeStep
prevRTS=RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon=prevRTS.month()
curStepMon=currentRuntimestep.month()
#print "prevMon, curMon = ", prevStepMon, curStepMon

#----------------------------------------------------------------------------------------
#if first of the month
if (prevStepMon<>curStepMon):
        if  ( CS_state == 4):
                DOps_state = Constants.TRUE
                EDOflow = Constants.FALSE
        elif (CS_state == 5):
                DOps_state = Constants.TRUE
                EDOflow = Constants.TRUE
        elif (DOps_state_prev and CS_state == 3):
                DOps_state = Constants.TRUE
                EDOflow = Constants.FALSE
        elif (DOps_state_prev and CS_state == 2):
                DOps_state = Constants.TRUE
                EDOflow = Constants.FALSE
        else:
                DOps_state = Constants.FALSE
                EDOflow = Constants.FALSE

        # If Feb is in drought, drought ops is extended to March.
        if (DOps_state_prev and prevStepMon==2):
                DOps_state = Constants.TRUE

# Is the DO new
        if      DOps_state:
                if not DOps_state_prev:
                #DO is new
                        Hold_RR = Constants.TRUE
                        Min_Reached=0
                        #override Min_reached_prev to an appropriate value to use if we get an immediate ramp rate
suspension(In the any day suspension check)
                        Min_Reached_prev=JWD_Q_prev2

                elif EDOflow and not EDOflow_prev:
                #EDO is new
                        if not Hold_RR_prev and Min_Reached_prev==0:
                        # if we are not in suspension, reactivate Hold_RR
                                Hold_RR = Constants.TRUE
                                Min_Reached=JWD_Q_prev
                        elif Hold_RR_prev:
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                        #we are in suspension, maintain suspension, and decide in any day section below
                                Hold_RR = Constants.FALSE
                                Min_Reached=Min_Reached_prev

                elif Hold_RR_prev:
                #DO is not new , check if RR still holds
                        Hold_RR = Constants.TRUE
                        Min_Reached=Min_Reached_prev

                elif not Hold_RR_prev and Min_Reached_prev>0:
                # we are in suspension
                        Hold_RR = Constants.FALSE
                        Min_Reached=Min_Reached_prev
```

```
        else:
        # Not DO
                Hold_RR = Constants.FALSE
                Min_Reached=Min_Reached_prev
#------------------------------------------------------------------------------------
#else other days in the month
else:
        DOps_state=DOps_state_prev
        EDOflow= EDOflow_prev

        Hold_RR = Hold_RR_prev
        Min_Reached=Min_Reached_prev

#------------------------------------------------------------------------------------
#------------------------------------------------------------------------------------
#Any day of the month and check for suspending Hold_RR
if DOps_state:
        if Hold_RR:
        #have we reached our target Min(4550 or 5050)?
                if EDOflow:
                        if JWD_Q_prev>4550:
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                Hold_RR = Constants.FALSE
                                Min_Reached=0
                else:
                        if JWD_Q_prev>5050:
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                Hold_RR = Constants.FALSE
                                Min_Reached=0

        #Is the release rising?(Do we need to suspend?) and DO is not new
        if Hold_RR:
                if DOps_state_prev:
                        if (JWD_Q_prev2<JWD_Q_prev):
                                Hold_RR = Constants.FALSE
                                Min_Reached=Min_Reached_prev

        # Is the Hold_RR suspended?
        else:
                if Min_Reached>0:
                        #Reach the min limit+Buffer
                        if JWD_Q_prev<Min_Reached_prev+Buffer:
                                #resume Hold_RR
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                #maintain suspension
                                Min_Reached=Min_Reached_prev
                                Hold_RR = Constants.FALSE
else:
        Hold_RR = Constants.FALSE
        Min_Reached=0

#message =  currentRuntimestep.dateTimeString() + "\tDOps_state " + `DOps_state` + "current value\n"
#network.printLogMessage(message)

EDOflowSV.setValue(currentRuntimestep,EDOflow)
Hold_RR_SV.setValue(currentRuntimestep,Hold_RR)
Min_Reached_SV.setValue(currentRuntimestep,Min_Reached)
```

```
currentVariable.setValue(currentRuntimestep, DOps_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...
```

Drought_Ops_4_3

```
#####
##### 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 state variable, called "Drought_Ops_4_3", determines at the beginning of every month whether or
# not the system's Composite Storage is within the drought zones, or the Exceptional Drought Trigger zone.
# The drought operation is turned on when the composite storage falls into Composite Zone 4 and
# remains in effect until the composite storage returns to composite storage Zone 3.

# “Hold_RR” and “Min_reached” slave sttae variables are used to maintain the RIOP-Falling Ramp Rate rule when
# Drought operation first occurs until the target # minimum flow is reached, at which point the RIOP-Falling
# Ramp Rate is suspended.  The target minimum flow # is 5050 cfs during Drought Operation (DO) and 4550 cfs
# during Exceptional Drought Operation (EDO).

from hec.script import Constants
#Buffer is a parameter to adjust the trigger for resuming RR after a temporarily suspension (unit=cfs)
Buffer=200
# ----------------------------------------------------------------------------------------------------------------------
# Read input state variable time series & value @ current run time step
# ----------------------------------------------------------------------------------------------------------------------

CS_state = network.getStateVariable("CompositeStorage").getValue(currentRuntimestep)

JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
JWD_Q_prev=JWD_Q_TS.getPreviousValue(currentRuntimestep)
JWD_Q_prev2=JWD_Q_TS.getLaggedValue(currentRuntimestep, 2)

#message =  "\n\n\n" + currentRuntimestep.dateTimeString() + "\tCompositeStorage " + `CS_state`
#network.printLogMessage(message)

DOps_state_prev = currentVariable.getPreviousValue(currentRuntimestep)

EDOflowSV = network.getStateVariable("EDO_Flow")
EDOflow_prev = EDOflowSV.getPreviousValue(currentRuntimestep)

Hold_RR_SV = network.getStateVariable("Hold_RR")
Hold_RR_prev = Hold_RR_SV.getPreviousValue(currentRuntimestep)

Min_Reached_SV=network.getStateVariable("Min_Reached")
Min_Reached_prev=Min_Reached_SV.getPreviousValue(currentRuntimestep)

# ----------------------------------------------------------------------------------------------------------------------
# Check the Composite Storage State at the Beginning of every month
# ----------------------------------------------------------------------------------------------------------------------

mon = currentRuntimestep.getHecTime().month()
day = currentRuntimestep.getHecTime().day()
hour = currentRuntimestep.getHecTime().hour()

#message =  currentRuntimestep.dateTimeString() + "\tmon " + `mon`
#network.printLogMessage(message)
```

```
#message =  currentRuntimestep.dateTimeString() + "\tday " + `day`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\thour " + `hour`
#network.printLogMessage(message)

from hec.model import RunTimeStep
prevRTS=RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon=prevRTS.month()
curStepMon=currentRuntimestep.month()
#print "prevMon, curMon = ", prevStepMon, curStepMon

#-----------------------------------------------------------------------------------------
#if first of the month
if (prevStepMon<>curStepMon):
		if  ( CS_state == 4):
				DOps_state = Constants.TRUE
				EDOflow = Constants.FALSE
		elif (CS_state == 5):
				DOps_state = Constants.TRUE
				EDOflow = Constants.TRUE
#		elif (DOps_state_prev and CS_state == 3):
#				DOps_state = Constants.TRUE
#				EDOflow = Constants.FALSE
#		elif (DOps_state_prev and CS_state == 2):
#				DOps_state = Constants.TRUE
#				EDOflow = Constants.FALSE
		else:
				DOps_state = Constants.FALSE
				EDOflow = Constants.FALSE

		# If Feb is in drought, drought ops is extended to March.
		if (DOps_state_prev and prevStepMon==2):
				DOps_state = Constants.TRUE

# Is the DO new
		if		DOps_state:
				if not DOps_state_prev:
				#DO is new
						Hold_RR = Constants.TRUE
						Min_Reached=0
						#override Min_reached_prev to an appropriate value to use if we get an immediate ramp rate
suspension(In the any day suspension check)
						Min_Reached_prev=JWD_Q_prev2

				elif EDOflow and not EDOflow_prev:
				#EDO is new
						if not Hold_RR_prev and Min_Reached_prev==0:
						# if we are not in suspension, reactivate Hold_RR
								Hold_RR = Constants.TRUE
								Min_Reached=JWD_Q_prev
						elif Hold_RR_prev:
								Hold_RR = Constants.TRUE
								if JWD_Q_prev<Min_Reached_prev:
										Min_Reached=JWD_Q_prev
								else:
										Min_Reached=Min_Reached_prev
						else:
						#we are in suspension, maintain suspension, and decide in any day section below
								Hold_RR = Constants.FALSE
								Min_Reached=Min_Reached_prev

				elif Hold_RR_prev:
				#DO is not new , check if RR still holds
						Hold_RR = Constants.TRUE
						Min_Reached=Min_Reached_prev

				elif not Hold_RR_prev and Min_Reached_prev>0:
				# we are in suspension
						Hold_RR = Constants.FALSE
						Min_Reached=Min_Reached_prev

		else:
```

```
        # Not DO
                Hold_RR = Constants.FALSE
                Min_Reached=Min_Reached_prev
#-------------------------------------------------------------------------------------
#else other days in the month
else:
        DOps_state=DOps_state_prev
        EDOflow= EDOflow_prev

        Hold_RR = Hold_RR_prev
        Min_Reached=Min_Reached_prev

#-------------------------------------------------------------------------------------
#-------------------------------------------------------------------------------------
#Any day of the month and check for suspending Hold_RR
if DOps_state:
        if Hold_RR:
        #have we reached our target Min(4550 or 5050)?
                if EDOflow:
                        if JWD_Q_prev>4550:
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                Hold_RR = Constants.FALSE
                                Min_Reached=0
                else:
                        if JWD_Q_prev>5050:
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                Hold_RR = Constants.FALSE
                                Min_Reached=0

        #Is the release rising?(Do we need to suspend?) and DO is not new
        if Hold_RR:
                if DOps_state_prev:
                        if (JWD_Q_prev2<JWD_Q_prev):
                                Hold_RR = Constants.FALSE
                                Min_Reached=Min_Reached_prev

        # Is the Hold_RR suspended?
        else:
                if Min_Reached>0:
                        #Reach the min limit+Buffer
                        if JWD_Q_prev<Min_Reached_prev+Buffer:
                                #resume Hold_RR
                                Hold_RR = Constants.TRUE
                                if JWD_Q_prev<Min_Reached_prev:
                                        Min_Reached=JWD_Q_prev
                                else:
                                        Min_Reached=Min_Reached_prev
                        else:
                                #maintain suspension
                                Min_Reached=Min_Reached_prev
                                Hold_RR = Constants.FALSE
else:
        Hold_RR = Constants.FALSE
        Min_Reached=0

#message =  currentRuntimestep.dateTimeString() + "\tDOps_state " + `DOps_state` + "current value\n"
#network.printLogMessage(message)

EDOflowSV.setValue(currentRuntimestep,EDOflow)
Hold_RR_SV.setValue(currentRuntimestep,Hold_RR)
Min_Reached_SV.setValue(currentRuntimestep,Min_Reached)
currentVariable.setValue(currentRuntimestep, DOps_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...
```

Drought_Ops_3_1

```
#####
##### 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 state variable, called "Drought_Ops_3_1", determines at the beginning of every month whether or
# not the system's Composite Storage is within the drought zones, or the Exceptional Drought Trigger zone.
# The drought operation is turned on when the composite storage falls into Composite Zone 3 and
# remains in effect until the composite storage returns to composite storage Zone 1.

# “Hold_RR” and “Min_reached” slave sttae variables are used to maintain the RIOP-Falling Ramp Rate rule when
# Drought operation first occurs until the target # minimum flow is reached, at which point the RIOP-Falling
# Ramp Rate is suspended.  The target minimum flow # is 5050 cfs during Drought Operation (DO) and 4550 cfs
# during Exceptional Drought Operation (EDO).

from hec.script import Constants

#Buffer is a parameter to adjust the trigger for resuming RR after a temporarily suspension (unit=cfs)
Buffer=200
# -------------------------------------------------------------------------------------------------------------------
# Read input state variable time series & value @ current run time step
# -------------------------------------------------------------------------------------------------------------------

CS_state = network.getStateVariable("CompositeStorage").getValue(currentRuntimestep)

JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
JWD_Q_prev=JWD_Q_TS.getPreviousValue(currentRuntimestep)
JWD_Q_prev2=JWD_Q_TS.getLaggedValue(currentRuntimestep, 2)

#message =  "\n\n\n" + currentRuntimestep.dateTimeString() + "\tCompositeStorage " + `CS_state`
#network.printLogMessage(message)

DOps_state_prev = currentVariable.getPreviousValue(currentRuntimestep)

EDOflowSV = network.getStateVariable("EDO_Flow")
EDOflow_prev = EDOflowSV.getPreviousValue(currentRuntimestep)

Hold_RR_SV = network.getStateVariable("Hold_RR")
Hold_RR_prev = Hold_RR_SV.getPreviousValue(currentRuntimestep)

Min_Reached_SV=network.getStateVariable("Min_Reached")
Min_Reached_prev=Min_Reached_SV.getPreviousValue(currentRuntimestep)

# -------------------------------------------------------------------------------------------------------------------
# Check the Composite Storage State at the Beginning of every month
# -------------------------------------------------------------------------------------------------------------------

mon = currentRuntimestep.getHecTime().month()
day = currentRuntimestep.getHecTime().day()
hour = currentRuntimestep.getHecTime().hour()

#message =  currentRuntimestep.dateTimeString() + "\tmon " + `mon`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\tday " + `day`
```

```
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\thour " + `hour`
#network.printLogMessage(message)

from hec.model import RunTimeStep
prevRTS=RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon=prevRTS.month()
curStepMon=currentRuntimestep.month()
#print "prevMon, curMon = ", prevStepMon, curStepMon

#-------------------------------------------------------------------------------------
#if first of the month
if (prevStepMon<>curStepMon):
	if  ( CS_state == 3):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	elif  ( CS_state == 4):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	elif (CS_state == 5):
		DOps_state = Constants.TRUE
		EDOflow = Constants.TRUE
	elif (DOps_state_prev and CS_state == 2):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	else:
		DOps_state = Constants.FALSE
		EDOflow = Constants.FALSE

	# If Feb is in drought, drought ops is extended to March.
	if (DOps_state_prev and prevStepMon==2):
		DOps_state = Constants.TRUE

# Is the DO new
	if	DOps_state:
		if not DOps_state_prev:
		#DO is new
			Hold_RR = Constants.TRUE
			Min_Reached=0
			#override Min_reached_prev to an appropriate value to use if we get an immediate ramp rate 
suspension(In the any day suspension check)
			Min_Reached_prev=JWD_Q_prev2

		elif EDOflow and not EDOflow_prev:
		#EDO is new
			if not Hold_RR_prev and Min_Reached_prev==0:
			# if we are not in suspension, reactivate Hold_RR
				Hold_RR = Constants.TRUE
				Min_Reached=JWD_Q_prev
			elif Hold_RR_prev:
				Hold_RR = Constants.TRUE
				if JWD_Q_prev<Min_Reached_prev:
					Min_Reached=JWD_Q_prev
				else:
					Min_Reached=Min_Reached_prev
			else:
			#we are in suspension, maintain suspension, and decide in any day section below
				Hold_RR = Constants.FALSE
				Min_Reached=Min_Reached_prev

		elif Hold_RR_prev:
		#DO is not new , check if RR still holds
			Hold_RR = Constants.TRUE
			Min_Reached=Min_Reached_prev

		elif not Hold_RR_prev and Min_Reached_prev>0:
		# we are in suspension
			Hold_RR = Constants.FALSE
			Min_Reached=Min_Reached_prev

	else:
	# Not DO
```

```
				Hold_RR = Constants.FALSE
				Min_Reached=Min_Reached_prev
#---------------------------------------------------------------------------------------
#else other days in the month
else:
		DOps_state=DOps_state_prev
		EDOflow= EDOflow_prev

		Hold_RR = Hold_RR_prev
		Min_Reached=Min_Reached_prev

#---------------------------------------------------------------------------------------
#---------------------------------------------------------------------------------------
#Any day of the month and check for suspending Hold_RR
if DOps_state:
		if Hold_RR:
		#have we reached our target Min(4550 or 5050)?
				if EDOflow:
						if JWD_Q_prev>4550:
								Hold_RR = Constants.TRUE
								if JWD_Q_prev<Min_Reached_prev:
										Min_Reached=JWD_Q_prev
								else:
										Min_Reached=Min_Reached_prev
						else:
								Hold_RR = Constants.FALSE
								Min_Reached=0
				else:
						if JWD_Q_prev>5050:
								Hold_RR = Constants.TRUE
								if JWD_Q_prev<Min_Reached_prev:
										Min_Reached=JWD_Q_prev
								else:
										Min_Reached=Min_Reached_prev
						else:
								Hold_RR = Constants.FALSE
								Min_Reached=0

		#Is the release rising?(Do we need to suspend?) and DO is not new
		if Hold_RR:
				if DOps_state_prev:
						if (JWD_Q_prev2<JWD_Q_prev):
								Hold_RR = Constants.FALSE
								Min_Reached=Min_Reached_prev

		# Is the Hold_RR suspended?
		else:
				if Min_Reached>0:
						#Reach the min limit+Buffer
						if JWD_Q_prev<Min_Reached_prev+Buffer:
								#resume Hold_RR
								Hold_RR = Constants.TRUE
								if JWD_Q_prev<Min_Reached_prev:
										Min_Reached=JWD_Q_prev
								else:
										Min_Reached=Min_Reached_prev
						else:
								#maintain suspension
								Min_Reached=Min_Reached_prev
								Hold_RR = Constants.FALSE
else:
		Hold_RR = Constants.FALSE
		Min_Reached=0

#message =  currentRuntimestep.dateTimeString() + "\tDOps_state " + `DOps_state` + "current value\n"
#network.printLogMessage(message)

EDOflowSV.setValue(currentRuntimestep,EDOflow)
Hold_RR_SV.setValue(currentRuntimestep,Hold_RR)
Min_Reached_SV.setValue(currentRuntimestep,Min_Reached)
currentVariable.setValue(currentRuntimestep, DOps_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...
```

ProlongedLowFLow

```
#####
##### 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):

        currentVariable.localTimeSeriesNew("Min_JW_30")
        currentVariable.localTimeSeriesNew("Max_JW_30")

        return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT MAIN SECTION
#####

# This state variable, called "prolongedFlow", determines whether or not the system is within the prolonged low flow
# siuation. The prolonged low flow situation is triggered when flows have been low for a while(< 7,000 cfs for 30 days)
# and resumed when flows return to higher levels for a while (> 10,000 cfs for 30 days).

# written by Leila

# Get Jim Woodruff flow--------------------------------------------------------
JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
Prolonged_state_prev = currentVariable.getPreviousValue(currentRuntimestep)

PrevStep=currentRuntimestep.getPrevStep()
minJW=JWD_Q_TS.min(PrevStep,-29)
maxJW=JWD_Q_TS.max(PrevStep,-29)

# Store for analysis/QC purposes
MinJW_30=currentVariable.localTimeSeriesGet("Min_JW_30")
MinJW_30.setCurrentValue(currentRuntimestep, minJW)
MaxJW_30=currentVariable.localTimeSeriesGet("Max_JW_30")
MaxJW_30.setCurrentValue(currentRuntimestep, maxJW)

# if flow < 7,000 cfs for 30 days
if (maxJW <7000) :
        prolongedFlow=1
else:
        prolongedFlow=0


if (prolongedFlow==0)and (Prolonged_state_prev==1):
        # if flow > 10,000 cfs for 30 days.
        if (minJW>10000):
                # resume
                prolongedFlow=0
        else:
                prolongedFlow=1

currentVariable.setValue(currentRuntimestep,prolongedFlow)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()

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

# add your code here...
```

Seasons

```
#####
##### 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
#####

# Create a code for seasons. Used primarily for determination of spawning season in Appalaciacola River
# March thru May	= 1  Spawning
# June thru November		= 2  Non-Spawning
# Dec thru February= 3   Winter

curMon=currentRuntimestep.month()
if (curMon < 3):
		# Winter
		code = 3
elif (curMon <6):
		# Spawning
		code = 1
elif (curMon < 12):
		# Non-Spawning
		code = 2
else:
		# Winter
		code =3

currentVariable.setValue(currentRuntimestep,code)

#####
##### 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...
```

BIFallRate

```
#####
##### 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
#####


# Compute the rate of decrease in the basin inflow.  Using the previous two timesteps' values of
# the one-day basin inflow state variable, take the difference to determine fall rate.
# Compute the minimum release using the release from the previous timestep minus the fall rate.


# This State varibale is modified on 11/22/2013 during ACF working session on November 2013.The team realized that
# the sharp decreases (spike) in discharge occurred when flow were below 22,000 cfs.  These spikes resulted from 1
# day basin inflow rising and no limit on 1 day basin inflow falling ramp rate.The State variable is revisd to follow
# the 2ft rampdown limit rule for flow<22000 cfs when BI is rising.After this modification spikes were disappeared.


#Get one day previous and two days previous value of BI_1D state variable
BI_SV=network.getStateVariable("BI_1D")
BI_TS=BI_SV.getTimeSeries()
BI_prev=BI_TS.getPreviousValue(currentRuntimestep)
BI_prev2=BI_TS.getLaggedValue(currentRuntimestep, 2)
BI_prev1=BI_TS.getLaggedValue(currentRuntimestep, 1)

# print "BI_prev=",BI_prev," BI_prev1=",BI_prev1," BI_prev2=",BI_prev2

# Compute the rate of decrease in BI_1D basin inflow
DIFF=BI_prev2-BI_prev

Rel_Ts=network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
prev_Rel=Rel_Ts.getPreviousValue(currentRuntimestep)


# If pool rises
if (DIFF<=0):
	if prev_Rel<=22000:
		Fall_rate_Table = currentVariable.varGet("Fall_rate_Table")
		Delta_2ft=Fall_rate_Table.interpolateValue(prev_Rel)
		min_Rel=prev_Rel-Delta_2ft
	else:
		min_Rel=0
# If pool falls
else:
	min_Rel=prev_Rel-DIFF

if(min_Rel < 0):
	min_Rel=0

currentVariable.setValue(currentRuntimestep,min_Rel)

#####
##### 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...
```

BI_FMA7

This is a master state variable that determines the value for the BI_1D slave state variable.

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

from hec.script import Constants
from hec.heclib.util import intContainer
#---------------------------------------------------------------------------------------------------------------------------------------------------
# set up the local variables that will be used to keep this state variable from computing the majority of the
# script more than once per time step.  This function is called only once - before the timestep loop in the compute.
#---------------------------------------------------------------------------------------------------------------------------------------------------
#
#		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
#####

#---------------------------------------------------------------------------------------------------------------------------------------------------
# Compute the 7day forward moving average of the Basin Inflow.
# Along the way, compute today's basin inflow and store it to BI_1D
# written by MMM
# modified by JDK, 10-2-09 (per avg), 10-29-09 (lag), 6-6-10 (routing).
#------------------------------------------------------------------------------------------------------------------------------------------------------------------

#  Increase DebugLevel to have more messages print - keep this at 1 or 0 unless you are debugging the script.
DebugLevel = 1

# use checkStep to allow the major portion of this script to execute only once per timestep.  checkstep is setup in the initialization
section of this state var.
checkStep = currentVariable.varGet("checkStep")
curStep = currentRuntimestep.getStep()

if (curStep != checkStep.value):
		checkStep.value = curStep
		Buf_IN_TS = network.getTimeSeries("Reservoir","Buford", "Pool", "Flow-IN NET")
		Buf_IN = Buf_IN_TS.getPreviousValue(currentRuntimestep)
		Buf_IN_7 = Buf_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WP_IN_TS = network.getTimeSeries("Reservoir","West Point", "Pool", "Flow-IN NET")
		WP_IN = WP_IN_TS.getPreviousValue(currentRuntimestep)
		WP_IN_7 = WP_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WFG_IN_TS = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Flow-IN NET")
		WFG_IN = WFG_IN_TS.getPreviousValue(currentRuntimestep)
		WFG_IN_7 = WFG_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		JWD_IN_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-IN NET")
		JWD_IN = JWD_IN_TS.getPreviousValue(currentRuntimestep)
		JWD_IN_7 = JWD_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)
```

```
        if (DebugLevel  >= 6):
                print "    Buf_IN =", Buf_IN, "  WP_IN =", WP_IN, "  WFG_IN =", WFG_IN,"  JWD_IN =", JWD_IN

        Buf_Q_TS = network.getTimeSeries("Reservoir","Buford","Pool","Flow-OUT")
        WP_Q_TS = network.getTimeSeries("Reservoir","West Point","Pool","Flow-OUT")
        WFG_Q_TS = network.getTimeSeries("Reservoir","Walter F George","Pool","Flow-OUT")

        # The following commented lines implement lagging as performed in the CESAM
        # spreadsheet used operationally.  HOWEVER, since no routing in the ResSim model "yet",
        # no lagging is being done in this Basin Inflow calculation.  (Nov2008)
        # note: if we revert to the laggedValue version, the lags are increased by 1 period due to the overall 1 period lag in the
whole logic (Oct2009)
        # note2: as of 6-6-10, the basin model has been updated to reflect the same routing used to compute the unimpaired flow
data set.
        #       As such, the following lag times are used to represent the new routing:  Buf-WP: 3days; WP-WFG: 1day; WFG-
JW: 1day (overall, 5 days)
        #       Also, since we have reverted to the lag version, the lags are all increased by 1 to reflect the 1 period lag in the
logic (jdk 6-6-10)

        Buf_Q_i3 = Buf_Q_TS.getLaggedValue(currentRuntimestep, 6)
        WP_Q_i2 = WP_Q_TS.getLaggedValue(currentRuntimestep, 3)
        WFG_Q_i1 = WFG_Q_TS.getLaggedValue(currentRuntimestep, 2)

        Buf_Q_i3_7 = Buf_Q_TS.getPeriodAverage(currentRuntimestep, 7, 6)
        WP_Q_i2_7 = WP_Q_TS.getPeriodAverage(currentRuntimestep, 7, 3)
        WFG_Q_i1_7 = WFG_Q_TS.getPeriodAverage(currentRuntimestep, 7, 2)

        # Using "routed" logic, no route code commented out  (jdk 6-6-10)
        # Buf_Q_i3 = Buf_Q_TS.getPreviousValue(currentRuntimestep)
        # WP_Q_i2 = WP_Q_TS.getPreviousValue(currentRuntimestep)
        # WFG_Q_i1 = WFG_Q_TS.getPreviousValue(currentRuntimestep)

        # Buf_Q_i3_7 = Buf_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)
        # WP_Q_i2_7 = WP_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)
        # WFG_Q_i1_7 = WFG_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

        if (DebugLevel  >= 6):
                print "    Buf_Q_i3 =", Buf_Q_i3, "  WP_Q_i2=", WP_Q_i2, "  WFG_Q_i1=", WFG_Q_i1

        Buf_loc = Buf_IN
        WP_loc = WP_IN - Buf_Q_i3
        WFG_loc = WFG_IN - WP_Q_i2
        JWD_loc = JWD_IN - WFG_Q_i1

        Buf_loc_7 = Buf_IN_7
        WP_loc_7 = WP_IN_7 - Buf_Q_i3_7
        WFG_loc_7 = WFG_IN_7 - WP_Q_i2_7
        JWD_loc_7 = JWD_IN_7 - WFG_Q_i1_7

        BI1D = Buf_loc + WP_loc + WFG_loc + JWD_loc
        BIStVar = network.getStateVariable("BI_1D")
        BIStVar.setValue(currentRuntimestep, BI1D)

        BI7D = Buf_loc_7 + WP_loc_7 + WFG_loc_7 + JWD_loc_7
        currentVariable.setValue(currentRuntimestep, BI7D)

#       if (DebugLevel  >= 6):
#               message = "step %d \tBuf-In7 = %9.2f \tWP-In7= %9.2f \tWP-loc7= %9.2f \tWFG-In7= %9.2f \tWFG-loc7=
%9.2f \tJWD-In7= %9.2f \tJWD-loc7= %9.2f" % (currentRuntimestep.getStep(),
Buf_IN_7,WP_IN_7,WP_loc_7,WFG_IN_7,WFG_loc_7,JWD_IN_7,JWD_loc_7)
#               network.printLogMessage(message)

if (DebugLevel  >= 6):
        print "    Finished state Variable script BI_FMA7 for currentRuntimestep=", currentRuntimestep.dateTimeString(), "
BI1D=",BI1D, "   BI7D=", BI7D
```

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

#--------------------------------------------------------------------------------------------------------------------------------------------------------
# This routine is called at the end of the calculations.
# We're using it to release the memory for the local variables.
#--------------------------------------------------------------------------------------------------------------------------------------------------------

currentVariable.varsClear()
```

FLBI_FMA7

This is a master state variable that determines the value for the FLBI_1D slave state variable.

```
#####
##### 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 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.

		currentVariable.varPut("checkStep", intContainer(-1))
#		- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

#		Type of Year
		NormYears =  [
1939,1940,1942,1943,1945,1950,1952,1957,1959,1960,1961,1962,1963,1966,1967,1969,1970,1972,1974,1976,1977,1978,1979,1
980,1982,1983,1984,1985,1987,1989,1992,1993,1995,1996,1997,1998,2001,2002,2004,2005,2008 ]
		WetYears =  [ 1944,1946,1947,1948,1949,1953,1958,1964,1965,1971,1973,1975,1991,1994,2003 ]
		DryYears =  [ 1941,1951,1954,1955,1956,1968,1981,1986,1988,1990,1999,2000,2006,2007 ]

		currentVariable.varPut("WetYears", WetYears)
		currentVariable.varPut("DryYears", DryYears)
		currentVariable.varPut("NormYears", NormYears)


#   Demand Table
		Wet_demand = [-85,127,92,584,970,1104,827,1236,1222,831,525,356 ]
		Dry_demand = [152,246,592,1231,1873,2173,2080,2149,1882,1119,660,437 ]
		Norm_demand = [22,107,257,825,1374,1419,1499,1519,1188,912,339,230 ]

		currentVariable.varPut("Wet_demand", Wet_demand)
		currentVariable.varPut("Dry_demand", Dry_demand)
		currentVariable.varPut("Norm_demand", Norm_demand)

		currentVariable.localTimeSeriesNew("FLBI_1D_WOdemand")
		currentVariable.localTimeSeriesNew("FLBI_7D_WOdemand")

		return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT MAIN SECTION
#####

# no return values are used by the compute from this script.
#
# 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

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
		checkStep.value = current_step

#-----------------------------------------------------------------------------------------------------------------
#   get state variable with functions
```

```
	functionSV = network.getStateVariable("functionHolder")
	functions = functionSV.varGet("functions")

# Get the current date as an HecTime object that reflects the true time of the step
	curTime = functions.getHecTimeFromRuntimestep(currentRuntimestep)
	curMonth = curTime.month()
	curDay = curTime.day()
	curYear = curTime.year()

#------------------------------------------------------------------------------------------------------------------------
	FLBI1D = network.getStateVariable("BI_1D").getValue(currentRuntimestep)
	FLBI7D = network.getStateVariable("BI_FMA7").getValue(currentRuntimestep)

	BIStVar_1D=currentVariable.localTimeSeriesGet("FLBI_1D_WOdemand")
	BIStVar_1D.setCurrentValue(currentRuntimestep, FLBI1D)

	BIStVar_7D=currentVariable.localTimeSeriesGet("FLBI_7D_WOdemand")
	BIStVar_7D.setCurrentValue(currentRuntimestep, FLBI7D)

	WetYears = currentVariable.varGet("WetYears")
	DryYears = currentVariable.varGet("DryYears")
	NormYears = currentVariable.varGet("NormYears")

	Wet_demand = currentVariable.varGet("Wet_demand")
	Dry_demand = currentVariable.varGet("Dry_demand")
	Norm_demand = currentVariable.varGet("Norm_demand")

	if curYear in WetYears:
		FLBI1D = FLBI1D + (Wet_demand[curMonth-1])
		FLBI7D = FLBI7D + (Wet_demand[curMonth-1])
	elif curYear in DryYears:
		FLBI1D = FLBI1D + (Dry_demand[curMonth-1])
		FLBI7D = FLBI7D + (Dry_demand[curMonth-1])
	else:
		FLBI1D = FLBI1D + (Norm_demand[curMonth-1])
		FLBI7D = FLBI7D + (Norm_demand[curMonth-1])


	FLBIStVar = network.getStateVariable("FLBI_1D")
	FLBIStVar.setValue(currentRuntimestep, FLBI1D)
	currentVariable.setValue(currentRuntimestep, FLBI7D)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()

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

# add your code here...
```

GABI_FMA7

This is a master state variable that determines the values for the GABI_1D slave state variable.

```
#####
##### 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 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):
		# 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 MAIN SECTION
#####

#-----------------------------------------------------------------------------------------------------------------------------------------------
# Compute the 7day forward moving average of the Basin Inflow(Based on Georgia proposal).
# Along the way, compute today's basin inflow and store it to GABI_1D
# written by Leila(7-16-13)
#---------------------------------------------------------------------------------------------------------------------------------------------------------

# use checkStep to allow the major portion of this script to execute only once per timestep.  checkstep is setup in the initialization section of this state var.
checkStep = currentVariable.varGet("checkStep")
curStep = currentRuntimestep.getStep()

if (curStep != checkStep.value):
		checkStep.value = curStep
		Buf_IN_TS = network.getTimeSeries("Reservoir","Buford", "Pool", "Flow-IN NET")
		Buf_IN = Buf_IN_TS.getPreviousValue(currentRuntimestep)
		Buf_IN_7 = Buf_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WP_IN_TS = network.getTimeSeries("Reservoir","West Point", "Pool", "Flow-IN NET")
		WP_IN = WP_IN_TS.getPreviousValue(currentRuntimestep)
		WP_IN_7 = WP_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WFG_IN_TS = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Flow-IN NET")
		WFG_IN = WFG_IN_TS.getPreviousValue(currentRuntimestep)
		WFG_IN_7 = WFG_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		JWD_IN_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-IN NET")
		JWD_IN = JWD_IN_TS.getPreviousValue(currentRuntimestep)
		JWD_IN_7 = JWD_IN_TS.getPeriodAverage(currentRuntimestep, 7, 1)

#-----------------------------------------------------------------------------------------------
		Buf_Q_TS = network.getTimeSeries("Reservoir","Buford","Pool","Flow-OUT")
		Buf_Q = Buf_Q_TS.getPreviousValue(currentRuntimestep)
		Buf_Q_7 = Buf_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WP_Q_TS = network.getTimeSeries("Reservoir","West Point","Pool","Flow-OUT")
		WP_Q = WP_Q_TS.getPreviousValue(currentRuntimestep)
		WP_Q_7 = WP_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

		WFG_Q_TS = network.getTimeSeries("Reservoir","Walter F George","Pool","Flow-OUT")
		WFG_Q = WFG_Q_TS.getPreviousValue(currentRuntimestep)
```

```
        WFG_Q_7 = WFG_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

        JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
        JWD_Q = JWD_Q_TS.getPreviousValue(currentRuntimestep)
        JWD_Q_7 = JWD_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

#------------------------------------------------------------------------------------------------
        Buf_Stor = Buf_IN - Buf_Q
        WP_Stor = WP_IN - WP_Q
        WFG_Stor = WFG_IN - WFG_Q
        JWD_Stor = JWD_IN - JWD_Q

        Buf_Stor_7 = Buf_IN_7 - Buf_Q_7
        WP_Stor_7 = WP_IN_7 - WP_Q_7
        WFG_Stor_7 = WFG_IN_7 - WFG_Q_7
        JWD_Stor_7 = JWD_IN_7 - JWD_Q_7

        GABI1D = Buf_Stor + WP_Stor + WFG_Stor + JWD_Stor + JWD_Q
        GABIStVar = network.getStateVariable("GABI_1D")
        GABIStVar.setValue(currentRuntimestep, GABI1D)

        GABI7D = Buf_Stor_7 + WP_Stor_7 + WFG_Stor_7 + JWD_Stor_7 + JWD_Q_7
        currentVariable.setValue(currentRuntimestep, GABI7D)

#####
##### 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...
```

FL_FlowTarget

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

from hec.script import Constants
from hec.heclib.util import intContainer
from hec.client import ClientApp
from hec.io import TimeSeriesContainer
from hec.hecmath import  DSS
from hec.heclib.util import HecTime
#
# 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):
		# establish and initialize any variables local to the state variable that are needed from once script execution to another
		currentVariable.varPut("checkStep", intContainer(-1))
#		- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
		leapYears =  [1900,1904,1908,1912,1916,1920,1924,1928,1932,1936,1940,1944,1948,1952,1956,1960,
		1964,1968,1972,1976,1980,1984,1988,1992,1996,2000,2004,2008,2012,2016,2020,2024,2028,2032,2036,
		2040,2044,2048,2052,2056,2060,2064,2068,2072,2076,2080,2084,2088,2092,2096,2100,2104,2108,2112,
		2116,2120,2124,2128,2132,2136,2140,2144,2148,2152,2156,2160,2164,2168,2172,2176,2180,2184,2188,
		2192,2196,2200,2204,2208,2212,2216,2220,2224,2228,2232,2236,2240,2244,2248,2252,2256,2260,2264,
		2268,2272,2276,2280,2284,2288,2292,2296,2300 ]

		currentVariable.varPut("leapYears", leapYears)


#		7-Day Exceedance Tables EX75365 adjusted for the past 7 days, UP80365 to UP99365 adjusted for the upcomming 7
days.

		EX75365=[13480, 13883,	14179,	14470,	15150,	15570,	15643,	15580,	15580,	15426,	14776,
		14377,	14682,	14840,	15531,	15176,	15297,	15548,	15727,	15879,	16099,	17206,	17916,
		17755,	17615,	18121,	18103,	17969,	17988,	17328,	17714,	17683,	17269,	18091,	17954,
		18105,	19155,	20514,	20929,	20803,	20982,	21821,	21423,	21284,	21215,	21162,	21221,
		21168,	20990,	21114,	21996,	22408,	22833,	22940,	23200,	23204,	23572,	24689,	24602,
		23880,	23572,	23359,	23857,	23732,	24639,	25364,	25230,	24848,	24914,	25193,	24409,
		25342,	25315,	24865,	24578,	24779,	24956,	25317,	24514,	24244,	24333,	24646,	24628,
		24220,	25171,	25805,	25570,	24930,	24165,	23536,	22922,	23327,	23730,	23536,	22875,
		22457,	23069,	22628,	22879,	23625,	24041,	23041,	22720,	22289,	22186,	21743,	21427,
		20752,	20433,	20373,	20233,	19761,	19023,	18816,	18720,	18742,	18275,	17848,	17617,
		17491,	17655,	17637,	17626,	17292,	17243,	17489,	16878,	16308,	16348,	16438,	16592,
		16556,	16521,	15882,	15434,	15289,	15004,	14413,	13598,	13406,	13698,	13326,	12628,
		12629,	12415,	12458,	12532,	12712,	12477,	12225,	12144,	12327,	12814,	12964,	13008,
		12725,	12295,	11960,	11807,	11474,	11238,	11198,	11164,	10783,	10957,	11275,	11270,
		11401,	11391,	11579,	11867,	11679,	11560,	11508,	11539,	11624,	11520,	11430,	11346,
		11158,	11101,	10826,	10557,	10246,	10117,	10385,	10557,	10604,	10351,	10737,	10574,
		10627,	10607,	10582,	10586,	10819,	10970,	11060,	11061,	10986,	10882,	10630,	10629,
		10583,	10664,	10561,	10375,	10279,	10282,	10560,	10674,	10489,	10385,	10240,	10138,
		9909,	9723,	9617,	9609,	9559,	9501,	9652,	9792,	9903,	10126,	10086,	9981,
		9844,	9810,	9779,	9792,	9554,	9534,	9431,	9108,	9299,	9077,	8744,	8756,
		8492,	8524,	8443,	8223,	8052,	8461,	8556,	8620,	8614,	8689,	8668,	8491,
		8577,	8202,	8452,	8278,	8149,	7864,	8220,	8209,	8225,	8325,	8316,	8153,
		8252,	8137,	8249,	8296,	8230,	8337,	8363,	8342,	8606,	8697,	8849,	8873,
		8264,	8218,	8106,	7904,	8097,	7937,	7832,	7827,	7654,	7565,	7425,	7493,
		7471,	7499,	7557,	7563,	7574,	7582,	7502,	7642,	7731,	7676,	7877,	7867,
		7737,	7853,	8037,	8216,	8325,	8091,	8156,	8163,	8246,	8439,	8286,	8256,
		8305,	8454,	8423,	8298,	8408,	8464,	8512,	8571,	8574,	8588,	8691,	9191,
		9193,	9113,	9134,	9279,	9377,	9436,	9538,	9598,	9585,	9968,	10196,	10229,
		9970,	9954,	9826,	9716,	9722,	9838,	9761,	10177,	10157,	10027,	10160,	10331,
		10517,	10864,	11042,	11044,	11290,	11177,	11067,	11242,	11449,	11448,	11307,	11328,
		11627,	12034,	12337,	12766,	13545,	13586]
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		15782,	15345,	14964,	14590,	14556,	14460,	14365,	14979,	15309,	15443,	15609,	15500,
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9612,   9775,   9923,   9970,   10035,  10107,  10094,  10085,  10223,  10445,  10565,  10918,
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5260,   5255,   5260,   5293,   5296,   5267,   5252,   5257,   5243,   5231,   5210,   5236,
5261,   5368,   5389,   5565,   5724,   5733,   5740,   5745,   5732,   5761,   5787,   5798,
5816,   5825,   5892,   6160,   6243,   6268,   6235,   6210,   6149,   6146,   6126,   6082,
6050,   5913,   5804,   5703,   5613,   5580,   5578,   5576,   5581,   5563,   5530,   5510,
5494,   5590,   5604,   5636,   5647,   5675,   5610,   5553,   5465,   5456,   5528,   5582,
5610,   5662,   5671,   5673,   5682,   5711,   5755,   5779,   5776,   5784,   5784,   5777,
5794,   5758,   5712,   5640,   5662,   5650,   5621,   5615,   5634,   5736,   5773,   5762,
5744,   5667,   5464,   5411,   5396,   5383,   5473,   5635,   5618,   5600,   5585,   5553,
5515,   5490,   5502,   5675,   5848,   6033,   6212,   6317,   6324,   6325,   6327,   6365,
6524,   6734,   6511,   6365,   6651,   6653,   6702,   6747,   6738,   6579,   6553,   6549,
6558,   6535,   6500,   6600,   6982,   7204,   7325,   7461,   7451,   7724,   8444,   8000,
8159,   8440,   8380,   8195,   8018,   8010]
UP99365=[7368,  7408,   7569,   7708,   7638,   7511,   7338,   7242,   7226,   7336,   7524,
7493,   7512,   7529,   7552,   7716,   7998,   8291,   8807,   9336,   9722,   9712,   9703,
9587,   9575,   9664,   9657,   9615,   9554,   9520,   9503,   9482,   9460,   9443,   9450,
10172,  10690,  10361,  10123,  9781,   9561,   9348,   9323,   9401,   9551,   9708,   9814,
9925,   9697,   9350,   9233,   9371,   9511,   9548,   9223,   8978,   8954,   9183,   9555,
9726,   10093,  10566,  11038,  11514,  11653,  11565,  11458,  11357,  11505,  12136,  12472,
12699,  12657,  12599,  12756,  12901,  12920,  12560,  12232,  11952,  11670,  11444,  11277,
11114,  10985,  10916,  10910,  10983,  11150,  11384,  11594,  11796,  11981,  12083,  12075,
11923,  11435,  11002,  10712,  10648,  10471,  10191,  9866,   9584,   9279,   8978,   8824,
8922,   8773,   8603,   8187,   7876,   7699,   7543,   7420,   7366,   7322,   7274,   7258,
7272,   7508,   7901,   8010,   7928,   7585,   7381,   7344,   6977,   6560,   6330,   6223,
6191,   6157,   6137,   6135,   6127,   6112,   6090,   6027,   5944,   5852,   5753,   5636,
5514,   5378,   5294,   5230,   5200,   5169,   5160,   5150,   5111,   5071,   5019,   4984,
4942,   4899,   4867,   4913,   4957,   4957,   4953,   4960,   4975,   4982,   4940,   4872,
4858,   4853,   4843,   4833,   4827,   4814,   4812,   4810,   4798,   4782,   4771,   4762,
4774,   4800,   4830,   4859,   4861,   4859,   4863,   4914,   5006,   5096,   5150,   5220,
5273,   5345,   5383,   5406,   5418,   5421,   5415,   5403,   5368,   5339,   5322,   5253,
5175,   5144,   5116,   5107,   5115,   5137,   5174,   5174,   5109,   5012,   4884,   4825,
4828,   4766,   4756,   4758,   4759,   4748,   4731,   4735,   4765,   4778,   4784,   4777,
4775,   4803,   4827,   4878,   4922,   4930,   4943,   4954,   4948,   4995,   4939,   4915,
4907,   4948,   5163,   5365,   5380,   5375,   5376,   5458,   5572,   5511,   5387,   5308,
5299,   5301,   5386,   5395,   5396,   5384,   5372,   5379,   5400,   5425,   5426,   5407,
5398,   5372,   5302,   5247,   5210,   5201,   5203,   5209,   5213,   5209,   5194,   5184,
5191,   5277,   5290,   5293,   5299,   5306,   5284,   5223,   5181,   5189,   5257,   5282,
```

```
	5282,	5289,	5293,	5299,	5309,	5303,	5300,	5297,	5293,	5296,	5300,	5308,
	5316,	5321,	5315,	5290,	5281,	5277,	5277,	5281,	5281,	5316,	5335,	5337,
	5334,	5285,	5137,	4930,	4722,	4759,	4997,	5111,	5066,	5038,	5034,	5022,
	5012,	4999,	5014,	5024,	5056,	5082,	5103,	5120,	5132,	5155,	5176,	5205,
	5375,	5558,	5375,	5238,	5251,	5270,	5293,	5282,	5277,	5342,	5434,	5533,
	5641,	5864,	6161,	6480,	6607,	6733,	6822,	6845,	7046,	7317,	7285,	7411,
	7383,	7297,	7312,	7324,	7338,	7355]

	currentVariable.varPut("EX75365", EX75365)
	currentVariable.varPut("UP80365", UP80365)
	currentVariable.varPut("UP85365", UP85365)
	currentVariable.varPut("UP90365", UP90365)
	currentVariable.varPut("UP95365", UP95365)
	currentVariable.varPut("UP99365", UP99365)

	currentVariable.localTimeSeriesNew("FL_TCSMA7Zone")
	currentVariable.localTimeSeriesNew("FL_EX75")
	currentVariable.localTimeSeriesNew("FL_EX80")
	currentVariable.localTimeSeriesNew("FL_EX85")
	currentVariable.localTimeSeriesNew("FL_EX90")
	currentVariable.localTimeSeriesNew("FL_EX95")
	currentVariable.localTimeSeriesNew("FL_EX99")
	currentVariable.localTimeSeriesNew("BI7Dgt10k")
	currentVariable.localTimeSeriesNew("FL_Chatt60")
	currentVariable.localTimeSeriesNew("FL_Chatt_lt6k")
	currentVariable.localTimeSeriesNew("FL_UFMA7Zone")
	currentVariable.localTimeSeriesNew("FL_EXSTATUS")
	currentVariable.localTimeSeriesNew("FL_FLOW50")
	currentVariable.localTimeSeriesNew("FL_EXFLOW")

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -	# 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 MAIN SECTION
#####

# This state variable is used to compue the Florida  daily Flow Target.
# ----------------------------------------------------------------------------------------------------------------------
#  FL_FlowTarget
#  07/18/2013
#  written by Leila

# Bu pool Operating Inactive (Elevation=1035 ,  Storage=867600)
# WP pool Operating Inactive (Elevation=620  ,  Storage=298389)
# WG pool Operating Inactive (Elevation=184  ,  Storage=690000)
# ----------------------------------------------------------------------------------------------------------------------

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
	checkStep.value = current_step

# ----------------------------------------------------------------------------------------------------------------------
# OBTAIN COE CONSERVATION ZONE
# ----------------------------------------------------------------------------------------------------------------------

	CS_state_TS = network.getStateVariable("CompositeStorage").getTimeSeries()
	CS_state_7   = CS_state_TS.getPeriodAverage(currentRuntimestep, 7, 1)
	CS_state = round(CS_state_7)

	# Store for anlysis/QC purposes
	TCSMA7ZoneVar=currentVariable.localTimeSeriesGet("FL_TCSMA7Zone")
	TCSMA7ZoneVar.setCurrentValue(currentRuntimestep, CS_state)
# ----------------------------------------------------------------------------------------------------------------------
# OBTAIN  EXCEEDANCES
# ----------------------------------------------------------------------------------------------------------------------
	leapYears = currentVariable.varGet("leapYears")
	EX75Table = currentVariable.varGet("EX75365")
```

```
            UP80Table = currentVariable.varGet("UP80365")
            UP85Table = currentVariable.varGet("UP85365")
            UP90Table = currentVariable.varGet("UP90365")
            UP95Table = currentVariable.varGet("UP95365")
            UP99Table = currentVariable.varGet("UP99365")
#--------------------------------------------------------------------------------
#   get state variable with functions
            functionSV = network.getStateVariable("functionHolder")
            functions = functionSV.varGet("functions")


# Get the current date as an HecTime object that reflects the true time of the step
            curTime = functions.getHecTimeFromRuntimestep(currentRuntimestep)
            month = curTime.month()
#           daymonth =  curTime.day()
            day = curTime.dayOfYear()
            year = curTime.year()

            if year in leapYears:
                        if day == 60:
                                    EX75val  = (EX75Table[day-1] + EX75Table[day-1+1])/2
                                    UP80val  = (UP80Table[day-1] + UP80Table[day-1+1])/2
                                    UP85val  = (UP85Table[day-1] + UP85Table[day-1+1])/2
                                    UP90val  = (UP90Table[day-1] + UP90Table[day-1+1])/2
                                    UP95val  = (UP95Table[day-1] + UP95Table[day-1+1])/2
                                    UP99val  = (UP99Table[day-1] + UP99Table[day-1+1])/2

                        elif day > 60:
                                    EX75val  = EX75Table[day-1-1]
                                    UP80val  = UP80Table[day-1-1]
                                    UP85val  = UP85Table[day-1-1]
                                    UP90val  = UP90Table[day-1-1]
                                    UP95val  = UP95Table[day-1-1]
                                    UP99val  = UP99Table[day-1-1]
                        else:
                                    EX75val  = EX75Table[day-1]
                                    UP80val  = UP80Table[day-1]
                                    UP85val  = UP85Table[day-1]
                                    UP90val  = UP90Table[day-1]
                                    UP95val  = UP95Table[day-1]
                                    UP99val  = UP99Table[day-1]

            else:
                        EX75val  = EX75Table[day-1]
                        UP80val  = UP80Table[day-1]
                        UP85val  = UP85Table[day-1]
                        UP90val  = UP90Table[day-1]
                        UP95val  = UP95Table[day-1]
                        UP99val  = UP99Table[day-1]

#-----------------------------------------------------------------------------------
            # Store for analysis/QC purposes
            Ex75TS=currentVariable.localTimeSeriesGet("FL_EX75")
            Ex75TS.setCurrentValue(currentRuntimestep, EX75val)

            Ex80TS=currentVariable.localTimeSeriesGet("FL_EX80")
            Ex80TS.setCurrentValue(currentRuntimestep, UP80val)

            Ex85TS=currentVariable.localTimeSeriesGet("FL_EX85")
            Ex85TS.setCurrentValue(currentRuntimestep, UP85val)

            Ex90TS=currentVariable.localTimeSeriesGet("FL_EX90")
            Ex90TS.setCurrentValue(currentRuntimestep, UP90val)

            Ex95TS=currentVariable.localTimeSeriesGet("FL_EX95")
            Ex95TS.setCurrentValue(currentRuntimestep, UP95val)

            Ex99TS=currentVariable.localTimeSeriesGet("FL_EX99")
            Ex99TS.setCurrentValue(currentRuntimestep, UP99val)

# ---------------------------------------------------------------------------------------------------------------------
# Get the net BI_FMA7 and revised BI_FMA7(FLBI_FMA7) state variables
# ---------------------------------------------------------------------------------------------------------------------
```

```
        FLBI7D = network.getStateVariable("FLBI_FMA7").getValue(currentRuntimestep)
        BI7D = network.getStateVariable("BI_FMA7").getValue(currentRuntimestep)

        if (BI7D > 10000):
                BI7Dgt10k = 1
        else:
                BI7Dgt10k = 0

        # Store for anlysis/QC purposes
        BI7Dgt10kVar=currentVariable.localTimeSeriesGet("BI7Dgt10k")
        BI7Dgt10kVar.setCurrentValue(currentRuntimestep, BI7Dgt10k)
# ----------------------------------------------------------------------------------------------------------------------
# CALCULATE 60-day average
# ----------------------------------------------------------------------------------------------------------------------

        Chatt_state_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
        Chatt_state_60   = Chatt_state_TS.getPeriodAverage(currentRuntimestep, 60, 1)

        # Store for anlysis/QC purposes
        Chatt60Var=currentVariable.localTimeSeriesGet("FL_Chatt60")
        Chatt60Var.setCurrentValue(currentRuntimestep, Chatt_state_60)

        if (Chatt_state_60 < 6000):
                Chatt60lt6k = 1
        else:
                Chatt60lt6k = 0

        # Store for anlysis/QC purposes
        Chatt60lt6kVar=currentVariable.localTimeSeriesGet("FL_Chatt_lt6k")
        Chatt60lt6kVar.setCurrentValue(currentRuntimestep, Chatt60lt6k)
# ----------------------------------------------------------------------------------------------------------------------
# UFMA7 ZONES
# ----------------------------------------------------------------------------------------------------------------------
#        Storage                          Zone
#        ----------                       ----------
#       > 75% exceedance flow for that week     1 - High
#        <75% exceedance flow for that week     2 - Low

        if (FLBI7D > EX75val):
                UF_state = 1
        else:
                UF_state = 2

        # Store for anlysis/QC purposes
        UFMA7ZoneVar=currentVariable.localTimeSeriesGet("FL_UFMA7Zone")
        UFMA7ZoneVar.setCurrentValue(currentRuntimestep, UF_state)
# ----------------------------------------------------------------------------------------------------------------------
# FLOW REQUIREMENT
# ----------------------------------------------------------------------------------------------------------------------
        # CS_state == 0 is above conservation. For this table the minimum will be considered to be same as CS_state==1
        if (CS_state ==0) or (CS_state ==1) or  (CS_state ==2):
                # Mid to high range
                if (UF_state ==1):
                        FLOW50  =  max((FLBI7D-UP80val)/2,0)
                        EX = 80
                        EXFLOW  = UP80val
                        FLOWREQ =EXFLOW + FLOW50
                # Low range
                else:
                        FLOW50 = max((FLBI7D-UP85val)/2,0)
                        EX = 85
                        EXFLOW  = UP85val
                        FLOWREQ =EXFLOW + FLOW50

        elif (CS_state ==3) or (CS_state ==4) :
                # Mid to high range
                if (UF_state ==1):
                        FLOW50 = max((FLBI7D-UP90val)/2,0)
                        EX = 90
                        EXFLOW  = UP90val
                        FLOWREQ =EXFLOW + FLOW50

                        if (FLOWREQ < 6000)  :
```

```
                    FLOWREQ = 6000
        # Low range
        else:
            FLOW50 = max((FLBI7D-UP95val)/2,0)
            EX = 95
            EXFLOW  = UP95val
            FLOWREQ =EXFLOW + FLOW50

            # REDUCE MINIMUM FLOWS DURING INTERVAL BETWEEN DECEMBER AND FEBRUARY
            if (month == 12 ) or (month == 1 )  or (month ==  2 )   :
                EX = 95
                EXFLOW  = UP95val
                FLOWREQ = UP95val
                FLOW50 = 0
            if (FLOWREQ < 5000)  :
                FLOWREQ = 5000
    else:
        if (12>= month >=6) :
            if ( Chatt60lt6k  == 1  ) and ( BI7Dgt10k  == 1 ):
                FLOW50 = (BI7D-UP99val)/2
            else:
                FLOW50 = 0
        else:
            FLOW50 = 0

        EX = 99
        EXFLOW  = UP99val
        FLOWREQ =EXFLOW +FLOW50

        if (FLOWREQ < 5000)  :
            FLOWREQ = 5000


    # Store for anlysis/QC purposes
    StatusVar=currentVariable.localTimeSeriesGet("FL_EXSTATUS")
    StatusVar.setCurrentValue(currentRuntimestep, EX)

    Flow50Var=currentVariable.localTimeSeriesGet("FL_FLOW50")
    Flow50Var.setCurrentValue(currentRuntimestep, FLOW50)

    ExFlowVar=currentVariable.localTimeSeriesGet("FL_EXFLOW")
    ExFlowVar.setCurrentValue(currentRuntimestep, EXFLOW)


    # ResSim the value from this variable in order to run the  FL_FlowTarget Rule
    currentVariable.setValue(currentRuntimestep, FLOWREQ)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()

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

# add your code here...
```

GA_FlowTarget

This is a master state variable that determines the values for the Pulse slave state variable.

```
#####
##### 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 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.
	currentVariable.varPut("checkStep", intContainer(-1))
	#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	leapYears =  [ 1900,1904,1908,1912,1916,1920,1924,1928,1932,1936,1940,1944,1948,1952,1956,1960,
	1964,1968,1972,1976,1980,1984,1988,1992,1996,2000,2004,2008,2012,2016,2020,2024,2028,2032,2036,
	2040,2044,2048,2052,2056,2060,2064,2068,2072,2076,2080,2084,2088,2092,2096,2100,2104,2108,2112,
	2116,2120,2124,2128,2132,2136,2140,2144,2148,2152,2156,2160,2164,2168,2172,2176,2180,2184,2188,
	2192,2196,2200,2204,2208,2212,2216,2220,2224,2228,2232,2236,2240,2244,2248,2252,2256,2260,2264,
	2268,2272,2276,2280,2284,2288,2292,2296,2300 ]

	currentVariable.varPut("leapYears", leapYears)


	NO_Pulse=8

	currentVariable.localTimeSeriesNew("GA_Season")
	currentVariable.localTimeSeriesNew("Min_Obs_30")
	currentVariable.localTimeSeriesNew("FM_TOT")
	currentVariable.localTimeSeriesNew("Min_Obs_MA")
	currentVariable.localTimeSeriesNew("pulse_NO", NO_Pulse)

	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT MAIN SECTION
#####

## This state variable is used to compue the Georgia seasonal Flow Target.
# -----------------------------------------------------------------------------------------------------------------------
#  GA_FlowTarget
#  07/19/2013
#  written by Leila
# -----------------------------------------------------------------------------------------------------------------------
from hec.heclib.util import intContainer
from hec.script import Constants

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
	checkStep.value = current_step


# Get the time---------------------------------------------------------------------------
#   get state variable with functions
	functionSV = network.getStateVariable("functionHolder")
	functions = functionSV.varGet("functions")

# Get the current date as an HecTime object that reflects the true time of the step
	curTime  = functions.getHecTimeFromRuntimestep(currentRuntimestep)
	curMonth = curTime.month()
	curDay   = curTime.day()
	curYear  = curTime.year()
```

```
# Create a code for seasons-----------------------------------------------------------------
# March    = 1
# Apr-May    = 2
# Jun-Nov              = 3
# Dec-Feb              = 4

        if (curMonth < 3)or (curMonth == 12 ):
                code = 4
        elif (curMonth <4):
                code = 1
        elif (curMonth < 6):
                code = 2
        else:
                code =3

        # Store for analysis/QA purposes
        Season=currentVariable.localTimeSeriesGet("GA_Season")
        Season.setCurrentValue(currentRuntimestep, code)

# Get the current composite storage zone , EDO, and Drought Operation------------------------
        CS_state = network.getStateVariable("CompositeStorage").getValue(currentRuntimestep)
        EDO_Flow =network.getStateVariable("EDO_Flow").getValue(currentRuntimestep)
        Drought_Ops =network.getStateVariable("Drought_Ops_4_1").getValue(currentRuntimestep)

# Get the Previous 7 Day average flow--------------------------------------------------------
        JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
        JWD_Q = JWD_Q_TS.getPeriodAverage(currentRuntimestep, 7, 1)

# Get the GABI1D and GABI7D------------------------------------------------------------------
        GABI1D = network.getStateVariable("GABI_1D").getValue(currentRuntimestep)
        GABI7D = network.getStateVariable("GABI_FMA7").getValue(currentRuntimestep)

# Get the GABI7D Time series-----------------------------------------------------------------
        GABI7D_TS = network.getStateVariable("GABI_FMA7").getTimeSeries()

#Get pulse SV
        PulseSV = network.getStateVariable("Pulse")
#-----------------------------------------------------------------------------------------------
        leapYears = currentVariable.varGet("leapYears")
        if curYear in leapYears:
                ndays=60
        else:
                ndays=59

# define the previous step-------------------------------------------------------------------
        PrevStep=currentRuntimestep.getPrevStep()

        # If we are in April or May
        if (curMonth==4) or (curMonth==5):
                # Get the min observed moving 30-day flow
                minJW=JWD_Q_TS.min(PrevStep,-29)
                # Store for anlysis/QC purposes
                MinObs_30=currentVariable.localTimeSeriesGet("Min_Obs_30")
                MinObs_30.setCurrentValue(currentRuntimestep, minJW)

                # compute the cumulatibe BI in February and March (Depending on leap year and non-leap year, "ndays" is
changed)
                if (curDay==1) and(curMonth==4):
                        FM_Total=GABI7D_TS.getCumulativeTotal(PrevStep, ndays)
                        currentVariable.varPut("Cum_FM", FM_Total)
                else:
                        FM_Total=currentVariable.varGet("Cum_FM")
                # Store for anlysis/QC purposes
                TotalCum=currentVariable.localTimeSeriesGet("FM_TOT")
                TotalCum.setCurrentValue(currentRuntimestep, FM_Total)

        # Get the min observed March17-April15(MA) if we are in sub-period April16-April30
        if (curMonth==4) and(curDay==16):
                minJW_MA=JWD_Q_TS.min(PrevStep,-29)
                MinObs_MA=currentVariable.localTimeSeriesGet("Min_Obs_MA")
                MinObs_MA.setCurrentValue(currentRuntimestep, minJW_MA)
```

```
# Get Buford, West Point and Walter F George pool elevation
	BU_elev_Ts=network.getTimeSeries("Reservoir","Buford", "Pool", "Elev")
	BU_elev=BU_elev_Ts.getPreviousValue(currentRuntimestep)

	WP_elev_Ts=network.getTimeSeries("Reservoir","West Point", "Pool", "Elev")
	WP_elev=WP_elev_Ts.getPreviousValue(currentRuntimestep)

	WFG_elev_Ts=network.getTimeSeries("Reservoir","Walter F George", "Pool", "Elev")
	WFG_elev=WFG_elev_Ts.getPreviousValue(currentRuntimestep)


	pulse_TS=currentVariable.localTimeSeriesGet("pulse_NO")
	NO_Pulse=pulse_TS.getPreviousValue(currentRuntimestep)

# FLOWREQ computation ------------------------------------------------------------

# Drought_Ops
	if Drought_Ops==1:
		FLOWREQ=5000
		Pulse = Constants.FALSE
		if EDO_Flow==1:
			FLOWREQ=4500
			Pulse = Constants.FALSE
	elif (CS_state ==4) or(CS_state ==5):
		FLOWREQ=5000
		Pulse = Constants.FALSE
#	Zone 0,1,2,3
	else :
#		March
		if code==1:
			FLOWREQ=6500
			Pulse = Constants.FALSE

#		Apr1-May31
		elif code==2 :
			if FM_Total>2450000:
				FLOWREQ= min( 10500, minJW)
			elif GABI7D >= 10500:
				FLOWREQ=10500
			elif 10500>= GABI7D>=5000:
				FLOWREQ=GABI7D
			else:
				FLOWREQ=5000
			Pulse = Constants.FALSE

#			Apr16-Apr30
			if (curMonth==4) and (30>=curDay>=16):
				if (BU_elev>1066) and (WP_elev>632) and (WFG_elev>187):
					FLOWREQ=min(22500, max(10500, minJW_MA))

#		Jun-Nov
		elif code==3 :
			if (JWD_Q <5100) and (GABI1D>=10476):
				if NO_Pulse>=8:
					NO_Pulse=0
#					Do Pulse
					Pulse = Constants.TRUE
					if curMonth==6:
						FLOWREQ=14850
					elif curMonth==7:
						FLOWREQ=15500
					elif curMonth==8:
						FLOWREQ=14400
					elif curMonth==9:
						FLOWREQ=11200
					elif curMonth==10:
						FLOWREQ=10100
					else:
						FLOWREQ=10500
#				No pulse
				else:
					FLOWREQ=5000
					Pulse = Constants.FALSE
```

```
                        elif (JWD_Q <5100) and (10476>GABI1D>=7181):
                                if NO_Pulse>=8:
                                        NO_Pulse=0
#                                       Do Pulse
                                        Pulse = Constants.TRUE
                                        if curMonth==6:
                                                FLOWREQ=11600
                                        elif curMonth==7:
                                                FLOWREQ=11500
                                        elif curMonth==8:
                                                FLOWREQ=11100
                                        elif curMonth==9:
                                                FLOWREQ=8620
                                        elif curMonth==10:
                                                FLOWREQ=7420
                                        else:
                                                FLOWREQ=7980
#                               No Pulse
                                else:
                                        FLOWREQ=5000
                                        Pulse = Constants.FALSE
#                       BI<7412
                        else:
                                FLOWREQ=5000
                                Pulse = Constants.FALSE
#               Dec-Feb
                else:
                        FLOWREQ=5000
                        Pulse = Constants.FALSE


        NO_Pulse=NO_Pulse+1
        # Store for anlysis/QC purposes
        pulse=currentVariable.localTimeSeriesGet("pulse_NO")
        pulse.setCurrentValue(currentRuntimestep, NO_Pulse)

        PulseSV.setValue(currentRuntimestep,Pulse)

# ResSim the value from this variable in order to run the  GA_FlowTarget Rule
        currentVariable.setValue(currentRuntimestep, FLOWREQ)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()

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

# add your code here...
```

FWS_FlowTarget

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

from hec.script import Constants
from hec.heclib.util import intContainer
from hec.client import ClientApp
from hec.io import TimeSeriesContainer
from hec.heclib.util import HecTime

# 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):
	# establish and initialize any variables local to the state variable that are needed from once script execution to another
	currentVariable.varPut("checkStep", intContainer(-1))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#	Flow_Target

	Target_Z1=[19000,	21000,	21000,	21000,	19000,	14000,	12000,	12000,	10000,	10000,	10000,
	10000]
	Target_Z2=[17000,	19000,	19000,	19000,	17000,	14000,	10000,	10000,	10000,	10000,	10000,
	10000]
	Target_Z3=[10000,	10000,	14000,	14000,	10000,	10000,	10000,	10000,	10000,	10000,	10000,
	10000]
	Target_Z4=[5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,
	5000]

	currentVariable.varPut("Target_Z1", Target_Z1)
	currentVariable.varPut("Target_Z2", Target_Z2)
	currentVariable.varPut("Target_Z3", Target_Z3)
	currentVariable.varPut("Target_Z4", Target_Z4)
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#	Flow_Minimum

	Minimum_Z1=[17000,	17000,	17000,	17000,	17000,	12000,	10000,	10000,	10000,	10000,
	10000,	10000]
	Minimum_Z2=[17000,	17000,	17000,	17000,	10000,	8000,	7000,	7000,	6000,	5000,
	6000,	8000]
	Minimum_Z3=[5000,	5000,	8000,	8000,	8000,	5000,	5000,	5000,	5000,	5000,
	5000,	5000]
	Minimum_Z4=[5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,
	5000,	5000]

	currentVariable.varPut("Minimum_Z1", Minimum_Z1)
	currentVariable.varPut("Minimum_Z2", Minimum_Z2)
	currentVariable.varPut("Minimum_Z3", Minimum_Z3)
	currentVariable.varPut("Minimum_Z4", Minimum_Z4)
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -	# Return Constants.TRUE if
the initialization is successful and Constants.FALSE if it failed.
#	Flow_Augmentation

	Augmentation_Z1=[2000,	4000,	4000,	4000,	2000,	2000,	2000,	2000,	0,	0,
	0,	0]
	Augmentation_Z2=[0,	2000,	2000,	2000,	4000,	2000,	2000,	2000,	1500,	1500,
	1500,	1500]
	Augmentation_Z3=[1000,	2000,	3000,	3000,	2000,	1000,	1000,	1000,	1000,	1000,
	1000,	1000]
	Augmentation_Z4=[0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
	0,	0]

	currentVariable.varPut("Augmentation_Z1", Augmentation_Z1)
	currentVariable.varPut("Augmentation_Z2", Augmentation_Z2)
	currentVariable.varPut("Augmentation_Z3", Augmentation_Z3)
	currentVariable.varPut("Augmentation_Z4", Augmentation_Z4)
```

```
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -	# Return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
#	Flow_Target-Augmentation

	TarAug_Z1=[17000,	17000,	17000,	17000,	17000,	12000,	10000,	10000,	10000,	10000,
	10000,	10000]
	TarAug_Z2=[17000,	17000,	17000,	17000,	13000,	12000,	8000,	8000,	8500,	8500,
	8500,	8500]
	TarAug_Z3=[9000,	8000,	11000,	11000,	8000,	9000,	9000,	9000,	9000,	9000,	9000,
	9000]
	TarAug_Z4=[5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,	5000,
	5000]

	currentVariable.varPut("TarAug_Z1", TarAug_Z1)
	currentVariable.varPut("TarAug_Z2", TarAug_Z2)
	currentVariable.varPut("TarAug_Z3", TarAug_Z3)
	currentVariable.varPut("TarAug_Z4", TarAug_Z4)


	currentVariable.localTimeSeriesNew("TarAugZ1")
	currentVariable.localTimeSeriesNew("TarAugZ2")
	currentVariable.localTimeSeriesNew("TarAugZ3")
	currentVariable.localTimeSeriesNew("TarAugZ4")

	currentVariable.localTimeSeriesNew("TargetZ1")
	currentVariable.localTimeSeriesNew("TargetZ2")
	currentVariable.localTimeSeriesNew("TargetZ3")
	currentVariable.localTimeSeriesNew("TargetZ4")

	currentVariable.localTimeSeriesNew("MinimumZ1")
	currentVariable.localTimeSeriesNew("MinimumZ2")
	currentVariable.localTimeSeriesNew("MinimumZ3")
	currentVariable.localTimeSeriesNew("MinimumZ4")

	currentVariable.localTimeSeriesNew("BIAugZ1")
	currentVariable.localTimeSeriesNew("BIAugZ2")
	currentVariable.localTimeSeriesNew("BIAugZ3")
	currentVariable.localTimeSeriesNew("BIAugZ4")

	currentVariable.localTimeSeriesNew("Augmentation_Z1")
	currentVariable.localTimeSeriesNew("Augmentation_Z2")
	currentVariable.localTimeSeriesNew("Augmentation_Z3")
	currentVariable.localTimeSeriesNew("Augmentation_Z4")

	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT MAIN SECTION
#####

# This state variable is used to compue the FWS monthly Flow Target.
# ---------------------------------------------------------------------------------------------------------------------
#  FWS_FlowTarget
#  07/24/2013
#  written by Leila
# ---------------------------------------------------------------------------------------------------------------------

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
	checkStep.value = current_step

# ---------------------------------------------------------------------------------------------------------------------
#   get state variable with functions
	functionSV = network.getStateVariable("functionHolder")
	functions = functionSV.varGet("functions")

# Get the current date as an HecTime object that reflects the true time of the step
	curTime = functions.getHecTimeFromRuntimestep(currentRuntimestep)
	month = curTime.month()

#----------------------------------------------------------------------------------------------------------------------
```

```
#   get the current composite storage zone
        CS_state = network.getStateVariable("CompositeStorage").getValue(currentRuntimestep)
#------------------------------------------------------------------------------------------------------------------------
#   get Basin Inflow
        FWSBI7D = network.getStateVariable("BI_FMA7").getValue(currentRuntimestep)
#------------------------------------------------------------------------------------------------------------------------
        Target_Z1_t = currentVariable.varGet("Target_Z1")
        Target_Z2_t= currentVariable.varGet("Target_Z2")
        Target_Z3_t = currentVariable.varGet("Target_Z3")
        Target_Z4_t = currentVariable.varGet("Target_Z4")

        Minimum_Z1_t = currentVariable.varGet("Minimum_Z1")
        Minimum_Z2_t = currentVariable.varGet("Minimum_Z2")
        Minimum_Z3_t = currentVariable.varGet("Minimum_Z3")
        Minimum_Z4_t = currentVariable.varGet("Minimum_Z4")

        Augmentation_Z1_t = currentVariable.varGet("Augmentation_Z1")
        Augmentation_Z2_t = currentVariable.varGet("Augmentation_Z2")
        Augmentation_Z3_t = currentVariable.varGet("Augmentation_Z3")
        Augmentation_Z4_t = currentVariable.varGet("Augmentation_Z4")

        TarAug_Z1_t = currentVariable.varGet("TarAug_Z1")
        TarAug_Z2_t = currentVariable.varGet("TarAug_Z2")
        TarAug_Z3_t = currentVariable.varGet("TarAug_Z3")
        TarAug_Z4_t = currentVariable.varGet("TarAug_Z4")

        TargetZ1=Target_Z1_t[month-1]
        TargetZ2=Target_Z2_t[month-1]
        TargetZ3=Target_Z3_t[month-1]
        TargetZ4=Target_Z4_t[month-1]

        MinimumZ1=Minimum_Z1_t[month-1]
        MinimumZ2=Minimum_Z2_t[month-1]
        MinimumZ3=Minimum_Z3_t[month-1]
        MinimumZ4=Minimum_Z4_t[month-1]

        AugmentationZ1=Augmentation_Z1_t[month-1]
        AugmentationZ2=Augmentation_Z2_t[month-1]
        AugmentationZ3=Augmentation_Z3_t[month-1]
        AugmentationZ4=Augmentation_Z4_t[month-1]

        TarAugZ1=TarAug_Z1_t[month-1]
        TarAugZ2=TarAug_Z2_t[month-1]
        TarAugZ3=TarAug_Z3_t[month-1]
        TarAugZ4=TarAug_Z4_t[month-1]


        # Store for analysis/QC purposes
        TarAugVarZ1=currentVariable.localTimeSeriesGet("TarAugZ1")
        TarAugVarZ1.setCurrentValue(currentRuntimestep, TarAugZ1)
        TarAugVarZ2=currentVariable.localTimeSeriesGet("TarAugZ2")
        TarAugVarZ2.setCurrentValue(currentRuntimestep, TarAugZ2)
        TarAugVarZ3=currentVariable.localTimeSeriesGet("TarAugZ3")
        TarAugVarZ3.setCurrentValue(currentRuntimestep, TarAugZ3)
        TarAugVarZ4=currentVariable.localTimeSeriesGet("TarAugZ4")
        TarAugVarZ4.setCurrentValue(currentRuntimestep, TarAugZ4)

        TargetVarZ1=currentVariable.localTimeSeriesGet("TargetZ1")
        TargetVarZ1.setCurrentValue(currentRuntimestep, TargetZ1)
        TargetVarZ2=currentVariable.localTimeSeriesGet("TargetZ2")
        TargetVarZ2.setCurrentValue(currentRuntimestep, TargetZ2)
        TargetVarZ3=currentVariable.localTimeSeriesGet("TargetZ3")
        TargetVarZ3.setCurrentValue(currentRuntimestep, TargetZ3)
        TargetVarZ4=currentVariable.localTimeSeriesGet("TargetZ4")
        TargetVarZ4.setCurrentValue(currentRuntimestep, TargetZ4)

        MinimumVarZ1=currentVariable.localTimeSeriesGet("MinimumZ1")
        MinimumVarZ1.setCurrentValue(currentRuntimestep, MinimumZ1)
        MinimumVarZ2=currentVariable.localTimeSeriesGet("MinimumZ2")
        MinimumVarZ2.setCurrentValue(currentRuntimestep, MinimumZ2)
        MinimumVarZ3=currentVariable.localTimeSeriesGet("MinimumZ3")
        MinimumVarZ3.setCurrentValue(currentRuntimestep, MinimumZ3)
        MinimumVarZ4=currentVariable.localTimeSeriesGet("MinimumZ4")
```

```
            MinimumVarZ4.setCurrentValue(currentRuntimestep, MinimumZ4)

            Augmentation_Z1_Var=currentVariable.localTimeSeriesGet("Augmentation_Z1")
            Augmentation_Z1_Var.setCurrentValue(currentRuntimestep, AugmentationZ1)
            Augmentation_Z2_Var=currentVariable.localTimeSeriesGet("Augmentation_Z2")
            Augmentation_Z2_Var.setCurrentValue(currentRuntimestep, AugmentationZ2)
            Augmentation_Z3_Var=currentVariable.localTimeSeriesGet("Augmentation_Z3")
            Augmentation_Z3_Var.setCurrentValue(currentRuntimestep, AugmentationZ3)
            Augmentation_Z4_Var=currentVariable.localTimeSeriesGet("Augmentation_Z4")
            Augmentation_Z4_Var.setCurrentValue(currentRuntimestep, AugmentationZ4)

#-----------------------------------------------------------------------------------------------------------------------
            BIAugZ1=FWSBI7D+AugmentationZ1
            BIAugZ2=FWSBI7D+AugmentationZ2
            BIAugZ3=FWSBI7D+AugmentationZ3
            BIAugZ4=FWSBI7D+AugmentationZ4

            # Store for analysis/QC purposes
            BI_AugZ1=currentVariable.localTimeSeriesGet("BIAugZ1")
            BI_AugZ1.setCurrentValue(currentRuntimestep, BIAugZ1)
            BI_AugZ2=currentVariable.localTimeSeriesGet("BIAugZ2")
            BI_AugZ2.setCurrentValue(currentRuntimestep, BIAugZ2)
            BI_AugZ3=currentVariable.localTimeSeriesGet("BIAugZ3")
            BI_AugZ3.setCurrentValue(currentRuntimestep, BIAugZ3)
            BI_AugZ4=currentVariable.localTimeSeriesGet("BIAugZ4")
            BI_AugZ4.setCurrentValue(currentRuntimestep, BIAugZ4)
#------------------------------------------------------------------------------------------------------------------------
            if (CS_state ==0) or (CS_state ==1):
                        if FWSBI7D>TarAugZ1:
                                    FLOWREQ=TargetZ1
                        else:
                                    FLOWREQ=max(MinimumZ1,BIAugZ1)
            elif (CS_state ==2) :
                        if FWSBI7D>TarAugZ2:
                                    FLOWREQ=TargetZ2
                        else:
                                    FLOWREQ=max(MinimumZ2,BIAugZ2)
            elif (CS_state ==3) :
                        if FWSBI7D>TarAugZ3:
                                    FLOWREQ=TargetZ3
                        else:
                                    FLOWREQ=max(MinimumZ3,BIAugZ3)
            else :
                        if FWSBI7D>TarAugZ4:
                                    FLOWREQ=TargetZ4
                        else:
                                    FLOWREQ=max(MinimumZ4,BIAugZ4)

            # ResSim the value from this variable in order to run the  FL_FlowTarget Rule
            currentVariable.setValue(currentRuntimestep, FLOWREQ)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()

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

# add your code here...
```

Scripts for the State Variables used for

B. Required Power and Energy Tracking

- BufordActivePowerReq

BufordActivePowerReq

This is a master state variable that determines the values for the following slave state variables:

- BufordActiveEnergyReq
- WestPointActivePowerReq
- WestPointActiveEnergyReq
- WalterFGeorgeActivePowerReq
- WalterFGeorgeActiveEnergyReq

```
#####
##### 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.
#
# July 2009, SMO
# Updated November 2013, LO
#
# The BufordActivePowerReq script was revisited to account for changed
# power rules in the Alt(?) alternative.
#
# Jan 2010, SMO
#####################################################
#####################################################
# Calculates Active Power and Active Energy Required for:
#     Buford
#     West Point
#     Walter F. George
#####################################################

# ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#
# WARNING:                                    #
# This script could change a lot if zones and rules change #
#
# Do NOT turn this script on for Alt(?) runs & trials that use power-matching rules
# (try to reproduce power generated in the original Alt(?))
#
# All other runs besides Baseline are expected to have same zones
# & power as Alt(?)
# ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#


# Get the current alternative in order to determine
# which set of zones and rules should be used.
# This returns a value like this:
#  No-action--:No-action--
```

```
#  _No-action1-:No-action-- 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"
# testing...
#if curAlt[0:4] == "Base" :
#    print curAlt[0:10], "0-10"
# print "$$$$$$$$$$$$$$$$$$$$$$$$$$$$", curAlt, curAlt[0:10]

#if curAlt[0:8] == "550-AltB" :
#		print "AAAAAAA"
#		sys.exit()
if curAlt[0:5] == "NO-ac" :
		###################################################
		# Set up a List of zones & associated power rules
		# Updated to include Zone & Rule Defs for both No-action & Alt(?) Nov 2013
		###################################################

		#######################
		# No-action Zone & Rule Defs
		#######################
		# Buford
		# Top of Dam
		BufordTODRule = "No Power Rule"
		#Flood Control
		BufordFCRule = "Power Plant-FC_3HrsGen"
		# Conservation
		BufordZ1Rule = "Power Plant-Z1_3HrsGen"
		# Zone 2
		BufordZ2Rule = "Power Plant-Z2_2HrsGen"
		# Zone 3
		BufordZ3Rule = "Power Plant-Z3_2hrGen"
		# Zone 4 - Zone 5 (Operating Inactive)
		BufordZ4Rule = "No Power Rule"
		BufordZ5Rule = "No Power Rule"

		#West Point
		# Top of Dam
		WestPointTODRule = "No Power Rule"
		# Flood Control
		WestPointFCRule = "Power Plant-FC_4HrsGen"
		# Conservation
		WestPointConRule = "Power Plant-Z1_4HrsGen"
		# Zone 2
		WestPointZ2Rule = "Power Plant-Z2_2HrsGen"
		# Zone 3
		WestPointZ3Rule = "Power Plant-Z3_2HrsGen"
		# Zone 4
		WestPointZ4Rule = "No Power Rule"

		#Walter F George
		# Top of Dam
		WalterFGeorgeTODRule = "No Power Rule"
		# Max Flood
		WalterFGeorgeMFRule = "No Power Rule"
		# Flood Control
		WalterFGeorgeFCRule = "Power Plant-FC_4HrsGen"
		# Conservation
		WalterFGeorgeConRule = "Power Plant-Z1_4HrsGen"
		# Zone 2
		WalterFGeorgeZ2Rule = "Power Plant-Z2_2HrsGen"
		# Zone 3
		WalterFGeorgeZ3Rule = "Power Plant-Z3_2HrsGen"
		# Zone 4
		WalterFGeorgeZ4Rule = "No Power Rule"

else :
##################
# Alt(?) Zone & Rule Defs
#  - and other Alternatives using Alt(?) zones & power rules
```

```
##################

        # Buford
        # Top of Dam - this depends on whether we are in drought ops or not.
        BufordTODRuleDO = "No Power Rule"
        BufordTODRule = "No Power Rule"
        #Flood Control- this depends on whether we are in drought ops or not.
        BufordFCRuleDO ="Power Plant-2HrsGen_FC"
        BufordFCRule = "Power Plant-3HrsGen_FC"
        # Conservation - this depends on whether we are in drought ops or not.
        BufordZ1RuleDO = "Power Plant-2HrsGen_Z1"
        BufordZ1Rule = "Power Plant-3HrsGen_Z1"
        # Zone 2 - this depends on whether we are in drought ops or not.
        BufordZ2RuleDO = "Power Plant-1HrGen_Z2"
        BufordZ2Rule = "Power Plant-2HrsGen_Z2"
        # Zone 3 - this depends on whether we are in drought ops or not.
        BufordZ3RuleDO = "Power Plant-1HrGen_Z3"
        BufordZ3Rule = "Power Plant-2HrsGen_Z3"
        # Zone 4 - Zone 5 (Operating Inactive)
        BufordZ4RuleDO = "No Power Rule"
        BufordZ4Rule = "No Power Rule"
        BufordZ5RuleDO = "No Power Rule"
        BufordZ5Rule = "No Power Rule"

        #West Point
        # Top of Dam
        WestPointTODRule = "No Power Rule"
        # Flood Control
        WestPointFCRule = "Power Plant-FC_4HrsGen"
        # Conservation
        WestPointConRule = "Power Plant-Z1_4HrsGen"
        # Zone 2
        WestPointZ2Rule = "Power Plant-Z2_2HrsGen"
        # Zone 3
        WestPointZ3Rule = "Power Plant-Z3_2HrsGen"
        # Zone 4
        WestPointZ4Rule = "No Power Rule"

        #Walter F George
        # Top of Dam
        WalterFGeorgeTODRule = "No Power Rule"
        # Max Flood
        WalterFGeorgeMFRule = "No Power Rule"
        # Flood Control
        WalterFGeorgeFCRule = "Power Plant-FC_4HrsGen"
        # Conservation
        WalterFGeorgeConRule = "Power Plant-Z1_4HrsGen"
        # Zone 2
        WalterFGeorgeZ2Rule = "Power Plant-Z2_2HrsGen"
        # Zone 3
        WalterFGeorgeZ3Rule = "Power Plant-Z3_2HrsGen"
        # Zone 4
        WalterFGeorgeZ4Rule = "No Power Rule"

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

# Get Zone values
BufordFC = network.getTimeSeries("Reservoir","Buford", "Flood Control", "Elev-ZONE")
BufordCon = network.getTimeSeries("Reservoir","Buford", "Conservation", "Elev-ZONE")
BufordZ2 = network.getTimeSeries("Reservoir","Buford", "Zone 2", "Elev-ZONE")
BufordZ3 = network.getTimeSeries("Reservoir","Buford", "Zone 3", "Elev-ZONE")
BufordZ4 = network.getTimeSeries("Reservoir","Buford", "Zone 4", "Elev-ZONE")
BufordZ5 = network.getTimeSeries("Reservoir","Buford", "Operating Inactive", "Elev-ZONE")
WestPointFC = network.getTimeSeries("Reservoir","West Point", "Flood Control", "Elev-ZONE")
WestPointCon = network.getTimeSeries("Reservoir","West Point", "Conservation", "Elev-ZONE")
WestPointZ2 = network.getTimeSeries("Reservoir","West Point", "Zone 2", "Elev-ZONE")
WestPointZ3 = network.getTimeSeries("Reservoir","West Point", "Zone 3", "Elev-ZONE")
WestPointZ4 = network.getTimeSeries("Reservoir","West Point", "Zone 4", "Elev-ZONE")
WalterFGeorgeFC = network.getTimeSeries("Reservoir","Walter F George", "Flood Control", "Elev-ZONE")
WalterFGeorgeCon = network.getTimeSeries("Reservoir","Walter F George", "Conservation", "Elev-ZONE")
WalterFGeorgeZ2 = network.getTimeSeries("Reservoir","Walter F George", "Zone 2", "Elev-ZONE")
WalterFGeorgeZ3 = network.getTimeSeries("Reservoir","Walter F George", "Zone 3", "Elev-ZONE")
WalterFGeorgeZ4 = network.getTimeSeries("Reservoir","Walter F George", "Zone 4", "Elev-ZONE")
```

```
# Get previous elev for each Reservoir
Buford_Elev = network.getTimeSeries("Reservoir","Buford", "Pool", "Elev").getPreviousValue(currentRuntimestep)
WestPoint_Elev = network.getTimeSeries("Reservoir","West Point", "Pool", "Elev").getPreviousValue(currentRuntimestep)
WalterFGeorge_Elev = network.getTimeSeries("Reservoir","Walter F George", "Pool",
"Elev").getPreviousValue(currentRuntimestep)

# For Alt(?) runs only:
# Check to see whether Drought Ops are active, since the power rule can differ based on Drought Ops
if curAlt[0:5] == "NO-ac" :
   DO = 0
else :
   DO = network.getStateVariable("Drought_Ops_4_1").getPreviousValue(currentRuntimestep)


# ------------Set the correct Rule based on the Active Zone------------- #
#print "###", BufordCon.getCurrentValue(currentRuntimestep)
#if Buford_Elev > BufordCon.getCurrentValue(currentRuntimestep) :                    # Above Con Zone
# This line allows a small tolerance for encroachment into the flood zone
# at which the conservation pool's power requirement is used

if Buford_Elev > (BufordCon.getCurrentValue(currentRuntimestep)+ 0.0001)  :   # In FC Zone
   if DO == 1 :
      BufordRule = BufordFCRuleDO
   else :
      BufordRule = BufordFCRule
elif Buford_Elev > BufordZ2.getCurrentValue(currentRuntimestep) :                    # In Con Zone
   if DO == 1 :
      BufordRule = BufordZ1RuleDO
   else :
      BufordRule = BufordZ1Rule
elif Buford_Elev > BufordZ3.getCurrentValue(currentRuntimestep) :                    # In Zone 2
   if DO == 1 :
      BufordRule = BufordZ2RuleDO
   else :
      BufordRule = BufordZ2Rule
elif Buford_Elev > BufordZ4.getCurrentValue(currentRuntimestep) :                    # In Zone 3
   if DO == 1 :
      BufordRule = BufordZ3RuleDO
   else :
      BufordRule = BufordZ3Rule
elif Buford_Elev > BufordZ5.getCurrentValue(currentRuntimestep) :                    # In Zone 4
   if DO == 1 :
      BufordRule = BufordZ4RuleDO
   else :
      BufordRule = BufordZ4Rule
else :
                                                  # Below Zone 4
   BufordRule = BufordZ5Rule


if WestPoint_Elev > WestPointFC.getCurrentValue(currentRuntimestep) :      # Above FC
   WestPointRule = WestPointTODRule
if WestPoint_Elev > WestPointCon.getCurrentValue(currentRuntimestep) :     # In FC Zone
   WestPointRule = WestPointFCRule
elif WestPoint_Elev > WestPointZ2.getCurrentValue(currentRuntimestep) :    # In Con Zone
   WestPointRule = WestPointConRule
elif WestPoint_Elev > WestPointZ3.getCurrentValue(currentRuntimestep) :    # In Zone 2
   WestPointRule = WestPointZ2Rule
elif WestPoint_Elev > WestPointZ4.getCurrentValue(currentRuntimestep) :    # In Zone 3
   WestPointRule = WestPointZ3Rule
else :
   WestPointRule = WestPointZ4Rule                              # Below Zone 3


if WalterFGeorge_Elev > WalterFGeorgeFC.getCurrentValue(currentRuntimestep) :       # Above TOD
   WalterFGeorgeRule = WalterFGeorgeTODRule
if WalterFGeorge_Elev > WalterFGeorgeCon.getCurrentValue(currentRuntimestep) :      # In FC Zone
   WalterFGeorgeRule = WalterFGeorgeFCRule
elif WalterFGeorge_Elev > WalterFGeorgeZ2.getCurrentValue(currentRuntimestep) :     # In Con Zone
   WalterFGeorgeRule = WalterFGeorgeConRule
elif WalterFGeorge_Elev > WalterFGeorgeZ3.getCurrentValue(currentRuntimestep) :     # In Zone 2
```

```
    WalterFGeorgeRule = WalterFGeorgeZ2Rule
elif WalterFGeorge_Elev > WalterFGeorgeZ4.getCurrentValue(currentRuntimestep) :     # In Zone 3
    WalterFGeorgeRule = WalterFGeorgeZ3Rule
else :
    WalterFGeorgeRule = WalterFGeorgeZ4Rule                                # Below Zone 3

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



# ------------ Get the Power Required & Energy Required based on rule --------------#
if BufordRule == "No Power Rule" :
    BufordPowerReq = 0
    BufordEnergyReq = 0
else :
    BufordPowerReq = network.getTimeSeries("Reservoir","Buford", BufordRule, "Power-
REQUIRED").getCurrentValue(currentRuntimestep)
    BufordEnergyReq = network.getTimeSeries("Reservoir","Buford", BufordRule, "Energy-
REQUIRED").getCurrentValue(currentRuntimestep)
if WestPointRule == "No Power Rule" :
    WestPointPowerReq = 0
    WestPointEnergyReq = 0
else :
    WestPointPowerReq = network.getTimeSeries("Reservoir","West Point", WestPointRule, "Power-
REQUIRED").getCurrentValue(currentRuntimestep)
    WestPointEnergyReq = network.getTimeSeries("Reservoir","West Point", WestPointRule, "Energy-
REQUIRED").getCurrentValue(currentRuntimestep)
if WalterFGeorgeRule == "No Power Rule" :
    WalterFGeorgePowerReq = 0
    WalterFGeorgeEnergyReq = 0
else :
    WalterFGeorgePowerReq = network.getTimeSeries("Reservoir","Walter F George", WalterFGeorgeRule, "Power-
REQUIRED").getCurrentValue(currentRuntimestep)
    WalterFGeorgeEnergyReq = network.getTimeSeries("Reservoir","Walter F George", WalterFGeorgeRule, "Energy-
REQUIRED").getCurrentValue(currentRuntimestep)


# -----------------------------------------
# Required Set Power & Energy
# -----------------------------------------
currentVariable.setValue(currentRuntimestep, BufordPowerReq)
network.getStateVariable("BufordActiveEnergyReq").setValue(currentRuntimestep, BufordEnergyReq)
network.getStateVariable("WestPointActivePowerReq").setValue(currentRuntimestep, WestPointPowerReq)
network.getStateVariable("WestPointActiveEnergyReq").setValue(currentRuntimestep, WestPointEnergyReq)
network.getStateVariable("WalterFGeorgeActivePowerReq").setValue(currentRuntimestep, WalterFGeorgePowerReq)
network.getStateVariable("WalterFGeorgeActiveEnergyReq").setValue(currentRuntimestep, WalterFGeorgeEnergyReq)



#####
##### 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...
```

Script for the State Variables used for

C. Gulf Sturgeon Spawning Operational Consideration

- MinStage_Chattahoochee

MinStage_Chattahoochee

```
#####
##### 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
#####

# MinStage_Chattahoochee state variable.
#
# Calculated to equal maximum 8' drop over a 2  week moving window
# during Sturgeon spawning season:
#	March thru May.
# Applies only when flows are less than 40,000 cfs.
# When flows are greater than 40,000, the minimum stage should be
# 8' below stage at 40,000 cfs.This is a "magic" number as it represents
#  the point at which a favored spawning habitat becomes exposed.
# However, in the regulation, there's no language that states that the pool
# can not drop more than 8', so we could set the minimum stage to zero.

curMon=currentRuntimestep.month()
if (curMon > 2 and curMon < 6):
	jwRelTS=network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
	jwMaxRel14=jwRelTS.max(currentRuntimestep.getPrevStep(), -13)
	if (jwMaxRel14 < 40000):
		jwElevTS=network.getTimeSeries("Reservoir","Jim Woodruff", "Dam Tailwater", "Elev-TAILWATER")
		jwElev14=jwElevTS.getLaggedValue(currentRuntimestep, 14)
		minElev  =    jwElev14 - 8
	else:
		minElev=45.7
else:
	minElev=38

currentVariable.setValue(currentRuntimestep,minElev)

#####
##### 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...
```

Scripts for the State Variables used for

D. Fish Spawning Operational Consideration

- Buford_Elev_State
- WestPoint_Elev_State
- WalterFGeorge_Elev_State
- JimWoodruff_ Elev_State

Buford_Elev_State

This is a master state variable that determines the value of the slave state variables Buford_BaseElev and Buford_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
#####

# Create a code to track the lake state due to rising/falling during the fish spawning period for Lake Sidney Lanier
# April thru May		= Spawning (code = 0-7, see below)
# Other times		= Non-Spawning (code = -1)

# State variable: Buford_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

prevRuntimestep=RunTimeStep(currentRuntimestep)
prevRuntimestep.setStep(currentRuntimestep.getPrevStep())
prevMon=prevRuntimestep.month()
curMon=currentRuntimestep.month()

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

if (curMon==4) and (curMon<>prevMon):
		# First day of spawning season (March 1st)
		LL_ELEV_TS = network.getTimeSeries("Reservoir","Buford", "Pool", "Elev")
		LL_ELEV = LL_ELEV_TS.getPreviousValue(currentRuntimestep)
		BaseElev = LL_ELEV
		Code =1
		BaseELEV_StVar=network.getStateVariable("Buford_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("Buford_FSCompliance")
		Num=1
		Days_StVar.setValue(currentRuntimestep,Num)

elif (curMon==4 ) or (curMon==5):
		# The rest of spawning season (March 2nd-April 30th)
		LL_ELEV_TS = network.getTimeSeries("Reservoir","Buford", "Pool", "Elev")
		LL_ELEV = LL_ELEV_TS.getPreviousValue(currentRuntimestep)
```

```
		BaseELEV_StVar=network.getStateVariable("Buford_BaseElev")
		BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)

		if BaseELEV_Pre < LL_ELEV:
			# Pool is rising, reset BaseELEV
			BaseELEV_Cur=LL_ELEV
			Code=0

		else :
			# Pool is steady or falling
			BaseELEV_Cur=BaseELEV_Pre

			Diff=BaseELEV_Pre - LL_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

		BaseELEV_StVar.setValue(currentRuntimestep, BaseELEV_Cur)

		Days_StVar= network.getStateVariable("Buford_FSCompliance")
		Count_Pre=Days_StVar.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)
	else:
		# not spawning season
		Code = -1
		currentVariable.setValue(currentRuntimestep, Code)

#####
##### 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...
```

WestPoint_Elev_State

This is a master state variable that determines the value of the slave state variables WestPoint_BaseElev and WestPoint_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
#####

# Create a code to track the lake state due to rising/falling during the fish spawning period for West Point Lake
# April thru May     = Spawning (code = 0-7, see below)
# Other times        = Non-Spawning (code = -1)

# State variable: WestPoint_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

prevRuntimestep=RunTimeStep(currentRuntimestep)
prevRuntimestep.setStep(currentRuntimestep.getPrevStep())
prevMon=prevRuntimestep.month()
curMon=currentRuntimestep.month()

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

if (curMon==4) and (curMon<>prevMon):
        # First day of spawning season (March 1st)
        WP_ELEV_TS = network.getTimeSeries("Reservoir","West Point", "Pool", "Elev")
        WP_ELEV = WP_ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseElev = WP_ELEV
        Code =1
        BaseELEV_StVar=network.getStateVariable("WestPoint_BaseElev")
        BaseELEV_StVar.setValue(currentRuntimestep,BaseElev)
        currentVariable.setValue(currentRuntimestep,Code)

        # Prep the counters for the number of days that the fish spawning requirements are met.
        Days_StVar= network.getStateVariable("WestPoint_FSCompliance")
        Num=1
        Days_StVar.setValue(currentRuntimestep,Num)

elif (curMon==4) or (curMon==5):
        # The rest of spawning season (April 2 thru May 30)
        WP_ELEV_TS = network.getTimeSeries("Reservoir","West Point", "Pool", "Elev")
```

```
        WP_ELEV = WP_ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseELEV_StVar=network.getStateVariable("WestPoint_BaseElev")
        BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)

        if BaseELEV_Pre < WP_ELEV:
                # Pool is rising, reset BaseELEV
                BaseELEV_Cur=WP_ELEV
                Code=0
        else :
                # Pool is steady or falling
                BaseELEV_Cur=BaseELEV_Pre

                Diff=BaseELEV_Pre - WP_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
        BaseELEV_StVar.setValue(currentRuntimestep, BaseELEV_Cur)

        Days_StVar= network.getStateVariable("WestPoint_FSCompliance")
        Count_Pre=Days_StVar.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)

else:
        # not spawning season
        Code = -1
        currentVariable.setValue(currentRuntimestep, Code)

#####
##### 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...
```

WalterFGeorge_Elev_State

```
#####
##### 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
#####

# Create a code to track the lake state due to rising/falling during the fish spawning period for Walter F. George Lake
# 15March - 15May = Spawning (code = 0-7, see below)
# Other times            = Non-Spawning (code = -1)

# State variable: WalterFGeorge_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
# defined as "BaseElev"

if (curMon==3) and (curDay == 15):
        # First day of spawning season (March 15th)
        WFG_ELEV_TS = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Elev")
        WFG_ELEV = WFG_ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseElev = WFG_ELEV
        Code =1
        BaseELEV_StVar=network.getStateVariable("WalterFGeorge_BaseElev")
        BaseELEV_StVar.setValue(currentRuntimestep,BaseElev)
        currentVariable.setValue(currentRuntimestep,Code)

        # Prep the counters for  the number of days that the fish spawning requirements are met.
        Days_StVar= network.getStateVariable("WalterFGeorge_FSCompliance")
        Num=1
        Days_StVar.setValue(currentRuntimestep,Num)

if (curMon==3 and curDay>15) or (curMon==4) or (curMon==5 and curDay <=15):
        # The rest of spawning season (March 16th-May15th)
        WFG_ELEV_TS = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Elev")
        WFG_ELEV = WFG_ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseELEV_StVar=network.getStateVariable("WalterFGeorge_BaseElev")
        BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)        if BaseELEV_Pre < WFG_ELEV:
                # Pool is rising, reset BaseELEV
                BaseELEV_Cur=WFG_ELEV
                Code=0
```

```
        else :
                # Pool is steady or falling
                BaseELEV_Cur=BaseELEV_Pre

                Diff=BaseELEV_Pre - WFG_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
        BaseELEV_StVar.setValue(currentRuntimestep, BaseELEV_Cur)

        Days_StVar= network.getStateVariable("WalterFGeorge_FSCompliance")
        Count_Pre=Days_StVar.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)
else:
        # not spawning season
        Code = -1
        currentVariable.setValue(currentRuntimestep, Code)

#####
##### 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...
```

JimWoodruff_ Elev_State

This is a master state variable that determines the value of the slave state variables JimWoodruff_BaseElev and JimWoodruff_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
#####

# Create a code to track the lake state due to rising/falling during the fish spawning period for Lake Seminole
# March thru April	= Spawning (code = 0-7, see below)
# Other times			= Non-Spawning (code = -1)

# State variable: JimWoodruff_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

prevRuntimestep=RunTimeStep(currentRuntimestep)
prevRuntimestep.setStep(currentRuntimestep.getPrevStep())
prevMon=prevRuntimestep.month()
curMon=currentRuntimestep.month()

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

if (curMon==3) and (curMon<>prevMon):
		# First day of spawning season (March 1st)
		LS_ELEV_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Elev")
		LS_ELEV = LS_ELEV_TS.getPreviousValue(currentRuntimestep)
		BaseElev = LS_ELEV
		Code =1
		BaseELEV_StVar=network.getStateVariable("JimWoodruff_BaseElev")
		BaseELEV_StVar.setValue(currentRuntimestep,BaseElev)
		currentVariable.setValue(currentRuntimestep,Code)

		# Prep the counters for the number of days that the fish spawning requirements are met.
		Days_StVar= network.getStateVariable("JimWoodruff_FSCompliance")
		Num=1
		Days_StVar.setValue(currentRuntimestep,Num)

elif (curMon==3) or (curMon==4):
		# The rest of spawning season (March 2nd-April 30th)
		LS_ELEV_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Elev")
```

```
        LS_ELEV = LS_ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseELEV_StVar=network.getStateVariable("JimWoodruff_BaseElev")
        BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)

        if BaseELEV_Pre < LS_ELEV:
                # Pool is rising, reset BaseELEV
                BaseELEV_Cur=LS_ELEV
                Code=0
        else :
                # Pool is steady or falling
                BaseELEV_Cur=BaseELEV_Pre

                Diff=BaseELEV_Pre - LS_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

        BaseELEV_StVar.setValue(currentRuntimestep, BaseELEV_Cur)

        Days_StVar= network.getStateVariable("JimWoodruff_FSCompliance")
        Count_Pre=Days_StVar.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)
else:
        # not spawning season
        Code = -1
        currentVariable.setValue(currentRuntimestep, Code)

#####
##### 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...
```

Scripts for the State Variables used for
E. Navigation Measures

- NavigationSeason
- BI_TriRivers_Calc
- NavQ_BI_TriRivers_Calc

NavigationSeason

```
#####
##### 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 code for navigation seasons

# 6 Mon; Dec thru May Navigation Season
# 1Dec - 31May          = 1 Navigation
# 1Jun - 30Nov          = 2 NO Navigation

# 5 Mon; Dec thru April Navigation Season
# 1Dec - 30Apr          = 1  Navigation
# 1May - 30Nov          = 2  NO Navigation

# 4 Mon; Jan thru April Navigation Season
# 1Jan - 30Apr          = 1  Navigation
# 1May - 31Dec          = 2  NO Navigation

# 5 Mon; Jan thru May Navigation Season
# 1Jan - 31May          = 1  Navigation
# 1Jun - 31Dec          = 2  NO Navigation

curMon=currentRuntimestep.month()
# for shorter Navigation season, change line below from 6 to 5 (or vice versa)
if (curMon < 6):
        code = 1
elif (curMon <13):
        code = 2
else:
        code =1
currentVariable.setValue(currentRuntimestep, code)

#####
##### 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...
```

BI_TriRivers_Calc

```
#####
##### 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 state variable is used to compute the release for Navigation from Jim Woodruff during March_May and when
# composite storage is equal to 1.
# When Basin Inflow >= min(16000;9ftNavQ-9ftAugmentation)
# release=max(16,000+50%BI>16,000 ; 9ftNavQ)

BI7D = network.getStateVariable("BI_FMA7").getValue(currentRuntimestep)
nineft_NavQ=18800

if BI7D>=16000:
		Rel=16000+0.5*(BI7D-16000)
else:
		Rel=16000

Release=max(Rel, nineft_NavQ)

currentVariable.setValue(currentRuntimestep, Release)

#####
##### 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...
```

NavQ_BI_TriRivers_Calc

```
#####
##### 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 MAIN SECTION
#####

# This state variable is used to compute the release for Navigation from Jim Woodruff during March_May and when
# composite storage is equal to 2.
# When Basin Inflow >= min(16000;9ftNavQ-9ftAugmentation)
# release=max(16,000+50%BI>16,000 ; 9ftNavQ+50%BI>9ftNavQ)

BI7D = network.getStateVariable("BI_FMA7").getValue(currentRuntimestep)
nineft_NavQ=18800

if BI7D>=16000:
	Rel1=16000+0.5*(BI7D-16000)
else:
	Rel1=16000

if BI7D>=nineft_NavQ:
	Rel2=nineft_NavQ+0.5*(BI7D-nineft_NavQ)
else:
	Rel2=nineft_NavQ

Release=max(Rel1,Rel2)

currentVariable.setValue(currentRuntimestep, Release)

#####
##### 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...
```

Scripts for the State Variables used for

F. Describing Physical Constraints at Walter F George and Jim Woodruff

- WalterFGeorge_MinTailwater
- JimWoodruff_MinTailwater

WalterFGeorge_MinTailwater

```
#####
##### 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
#####

#-----------------------------------------------------------------------------------------------------------
#compute Walter F George minimum tailwater elevation
# MinTail = Pool Elev - 88'
#-----------------------------------------------------------------------------------------------------------

wfgElev=network.getTimeSeries("Reservoir","Walter F George", "Pool", "Elev").getPreviousValue(currentRuntimestep)
minTail=wfgElev - 88
currentVariable.setValue(currentRuntimestep, minTail)

#####
##### 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...
```

JimWoodruff_MinTailwater

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

from hec.script import Constants
from hec.heclib.util import intContainer
#------------------------------------------------------------------------------------------------------------------------------------------------
# set up the local variables that will be used to make this state variable from computing the majority of the
# script only once per time step.

# return Constants.TRUE if the initialization is successful, Constants.FALSE if it failed.
# Returning Constants.FALSE will halt the compute.
#------------------------------------------------------------------------------------------------------------------------------------------------

def initStateVariable(currentVariable, network):
    currentVariable.varPut("checkStep", intContainer(-1))
    return Constants.TRUE

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

#------------------------------------------------------------------------------------------------------
# This state variable computes the minimum tailwater elevation based on the Maximum head limit curve provided by Andy Ashley,
SAM.
# It uses a locally defined function to do the lookup from the table below describing the head limit curve.

# Per Andy in Nov2008, the tailwater ratings will not control minimum releases at tailwater elevations below 38
# Modified Nov 2009 JDK - compute once per timestep; put warning messages under debug control variable.
#------------------------------------------------------------------------------------------------------

MaxPoolElev= [
[75.5,76.50,76.52,76.54,76.56,76.58,76.60,76.62,76.64,76.66,76.68,76.70,76.73,76.76,76.79,76.82,76.85,76.88,76.91,76.94,76.97,
 77.00,77.01,77.02,77.03,77.04,77.05,77.06,77.07,77.08,77.09,77.10,77.11,77.12,77.13,77.14,77.15,77.16,77.17,77.18,77.19,
 77.20,77.21,77.23,77.24,77.26,77.27,77.29,77.30,77.32,77.34,77.35,77.36,77.38,77.40,77.41,77.42,77.44,77.46,77.47,77.48,
 77.50,77.55,77.60,77.65,77.70,77.75,77.80,77.85,77.90,77.95,78.00],
[37.5,38., 38.1, 38.2, 38.3, 38.4, 38.5, 38.6, 38.7, 38.8, 38.9, 39., 39.1, 39.2, 39.3, 39.4, 39.5, 39.6, 39.7, 39.8, 39.9,
 40., 40.1, 40.2, 40.3, 40.4, 40.5, 40.6, 40.7, 40.8, 40.9, 41., 41.1, 41.2, 41.3, 41.4, 41.5, 41.6, 41.7, 41.8, 41.9,
 42., 42.1, 42.2, 42.3, 42.4, 42.5, 42.6, 42.7, 42.8, 42.9,43., 43.1, 43.2, 43.3, 43.4, 43.5, 43.6, 43.7, 43.8, 43.9,
 44., 44.1, 44.2, 44.3, 44.4, 44.5, 44.6, 44.7, 44.8, 44.9,45.]
 ]

#------------------------------------------------------------------------------------------------------
# Local function definitions
#------------------------------------------------------------------------------------------------------

# Linear Interpolation Function
def interpolate(x, x0, x1, y0, y1):
        y = y0 + (x - x0) * ( (y1-y0) / (x1-x0) )
        return y

# Lookup Function
def lookup(table, lookupVar):
        debugLevel = 1
        tableLen = len(table[0])
        for j in range(tableLen):
                if table[0][j] >= lookupVar and j==0:
                        i = j
                        returnVar = table[1][j]

                        if (debugLevel == 6 and table[0][j] > lookupVar):
                                message = "Warning: Woodruff_Head_Limits SV %s look-up value(%9.3f) is below table
limits (%9.3f) so return value set to first value in the table (%9.3f)" % \
                                        (currentRuntimestep.dateTimeString(), lookupVar, table[0][j], returnVar)
                                network.printWarningMessage(message)
                        break

                if table[0][j] >= lookupVar and ( 0 < j < tableLen ):
                        i = j-1
```

```
                    returnVar = interpolate(lookupVar, table[0][i], table[0][j], table[1][i], table[1][j])
                    break

            if table[0][j] < lookupVar and j == tableLen:
                    returnVar = table[1][-1]
                    i = j
                    break

            if table[0][-1] < lookupVar:
                    returnVar = table[1][-1]
                    i = j
                    if debugLevel == 6 :
                            message = "Warning: Woodruff_Head_Limits SV %s look-up value(%9.3f) is above table
limits (%9.3f) so return value set to last value in the table (%9.3f)" % \
                            (currentRuntimestep.dateTimeString(), lookupVar, table[0][-1], returnVar)
                            network.printWarningMessage(message)

                    break

    return returnVar

#---------------------------------------------------------------------------------------------------------
#  Main
#---------------------------------------------------------------------------------------------------------
checkStep=currentVariable.varGet("checkStep")
curStep = currentRuntimestep.getStep()
if (checkStep.value != curStep):
    checkStep.value = curStep
    prevElev = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Elev").getPreviousValue(currentRuntimestep)
    minTW = lookup(MaxPoolElev, prevElev)
    currentVariable.setValue(currentRuntimestep, minTW)

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

#---------------------------------------------------------------------------------------------------------------------------------------------------
# This routine is called at the end of the calculations.
# We're using it to release the memory for the local variables.
#---------------------------------------------------------------------------------------------------------------------------------------------------

currentVariable.varsClear()
```

G. Scripts for Other State Variables

- WestPoint_GCBuffer
- FloodSeasons

WestPoint_GCBuffer

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

from hec.script import Constants
from hec.heclib.util import intContainer
#

def initStateVariable(currentVariable, network):
#    currentVariable.varPut("checkStep", intContainer(-1))
   return Constants.TRUE

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

# determine if the pool elevation at the end of the last timestep is within 0.05' of the guide curve.
# if so, state=1, else state=0.

elev = network.getTimeSeries("Reservoir","West Point", "Pool", "Elev").getPreviousValue(currentRuntimestep)
gc = network.getTimeSeries("Reservoir","West Point", "Conservation", "Elev-ZONE").getPreviousValue(currentRuntimestep)
gcnext =network.getTimeSeries("Reservoir","West Point", "Conservation", "Elev-ZONE").getCurrentValue(currentRuntimestep)

if gc < gcnext:
        # rising limb of guide curve, the problem area
        gcHigh = gcnext+0.05
        gcLow = gc-0.05
        if (elev >= gcLow and elev <= gcHigh):
                state = 1
        else:
                state = 0
elif gc > gcnext:
        # falling limb of guide curve
        state = 0
else:
        # flat spot in guide curve
        gcHigh = gc+0.05
        gcLow = gc-0.05
        if (elev >= gcLow and elev <= gcHigh):
                state = 1
        else:
                state = 0

currentVariable.setValue(currentRuntimestep, 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...
```

FloodSeasons

```
#####
##### 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
#####

# Create a code for seasons for Induced Surcharge operations
# 15apr-19nov = 1  Summer
# 20nov-14apr = 2  Winter

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

if (curMon < 5):			#Jan-April 14
   if (curMon == 4):
      if(curDay <15):
         code = 2
      else:		#April 15-30
         code = 1
   else:
      code = 2
elif (curMon > 10):	#Nov-Dec
   if(curMon == 11):
      if(curDay > 19):
         code = 2
      else:		#Nov 1-19
         code = 1
   else:
      code = 2
else:			#May-Oct
   code = 1

currentVariable.setValue(currentRuntimestep,code)

#####
##### 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...
```

Scripts for the State Variables used for

H. Scripts for Proposed Reservoirs

- PumptoGlades
- PumptoBear

PumptoBear

```
#####
##### 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 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):
	# establish and initialize any variables local to the state variable that are needed from once script execution to another
	currentVariable.varPut("checkStep", intContainer(-1))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#	Chattahoochee_low flow requirment

	Ch_min=[ 1133,	1174,	1221,	1154,	1058,	1002,	977,	946,	955,	970,	1001,
	1056]

	currentVariable.varPut("Ch_min", Ch_min)

	currentVariable.localTimeSeriesNew("Ch_EPD")
	currentVariable.localTimeSeriesNew("avail_Ch_fl")
	currentVariable.localTimeSeriesNew("needed_flow")
	currentVariable.localTimeSeriesNew("DIV_needed")
	currentVariable.localTimeSeriesNew("Bear_Min")
	currentVariable.localTimeSeriesNew("BearDiv")
	currentVariable.localTimeSeriesNew("Ending_Stor_EST")
	return Constants.TRUE

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


# This state variable computes the diversion from Chattahoochee river to Bear.
# the lesser of the following volumes is computed and delivered to the reservoir:
# 1) The amount of pumping needed to refill the reservoir to 80% of full reservoir storage
#    (Approximately EL751 ft-Exactly EL 750.7906 ft)
# 2) The designated diversion pumping capacity
# 3) The diversion volume that can be accommodated considering Low Flow Requirements in the Chattahoochee River
#
# written by Leila_10/10/2013
# Updated 10/25/2013

# (Get back to EL 750.7906)
Refill_level=5380
# (Get back to EL 751)
#Refill_level=5464.5

#Inactive El=738 ft and its corresponding storage is equal to 1395 acft.
IA_Stor=1395
# ------------------------------------------------------------------------------------------------------------------------
#   get state variable with functions
functionSV = network.getStateVariable("functionHolder")
functions = functionSV.varGet("functions")


# Get the current date as an HecTime object that reflects the true time of the step
curTime = functions.getHecTimeFromRuntimestep(currentRuntimestep)
month = curTime.month()

#-------------------------------------------------------------------------------------------------------------------------
ChattInflow = network.getTimeSeries("Junction","US Bear Creek", "", "Flow")
ChattInflow_Cur = ChattInflow.getCurrentValue(currentRuntimestep)
BearSt = network.getTimeSeries("Reservoir","Bear Creek", "Pool", "Stor")
BearSt_Prev = BearSt.getPreviousValue(currentRuntimestep)
```

```
Bear_Evap=network.getTimeSeries("Reservoir","Bear Creek", "Pool", "Flow-EVAP")
Bear_Evap_Cur=Bear_Evap.getCurrentValue(currentRuntimestep)

BearIN_LOC=network.findJunction("Bear Creek_IN").getLocalFlowTimeSeries("Bear Creek_IN_LOC")
BearIN_LOC_Cur = BearIN_LOC.getCurrentValue(currentRuntimestep)


#--------------------------------------------------------------------------------------------------------------------------
# Get Chattahoochee EPD defined in the init tab
Ch_min_t = currentVariable.varGet("Ch_min")
Ch_EPD=Ch_min_t[month-1]

# Store for analysis/QC purposes
Ch_EPD_var=currentVariable.localTimeSeriesGet("Ch_EPD")
Ch_EPD_var.setCurrentValue(currentRuntimestep, Ch_EPD)
#--------------------------------------------------------------------------------------------------------------------------
# Computing available chatahoochee flow that could be diverted
if ChattInflow_Cur>Ch_EPD:
	avail_Ch_fl=ChattInflow_Cur-Ch_EPD
else:
	avail_Ch_fl=0

# Store for analysis/QC purposes
avail_Ch_fl_var=currentVariable.localTimeSeriesGet("avail_Ch_fl")
avail_Ch_fl_var.setCurrentValue(currentRuntimestep, avail_Ch_fl)
#--------------------------------------------------------------------------------------------------------------------------
#Computing the minimum Release from Bear
Bear_Min=min(3.1, BearIN_LOC_Cur)

# Store for analysis/QC purposes
Bear_Min_var=currentVariable.localTimeSeriesGet("Bear_Min")
Bear_Min_var.setCurrentValue(currentRuntimestep, Bear_Min)
#--------------------------------------------------------------------------------------------------------------------------
Avail_Flow = (BearSt_Prev - IA_Stor)/1.98 + BearIN_LOC_Cur - Bear_Min - Bear_Evap_Cur

BearDiv=min (25.4 , Avail_Flow)

if BearDiv < 25.4 :
	DIV_needed = 25.4 -BearDiv
else:
	DIV_needed =0

# Store for analysis/QC purposes
BearDiv_var=currentVariable.localTimeSeriesGet("BearDiv")
BearDiv_var.setCurrentValue(currentRuntimestep, BearDiv)

DIV_needed_var=currentVariable.localTimeSeriesGet("DIV_needed")
DIV_needed_var.setCurrentValue(currentRuntimestep, DIV_needed)
#--------------------------------------------------------------------------------------------------------------------------
#Estimating the ending storage at current time step to figure out how much flow is needed to get the Bear pool back to 80% of full
capacity
Ending_Stor_EST= BearSt_Prev +(BearIN_LOC_Cur - Bear_Min - BearDiv - Bear_Evap_Cur)*1.98

Ending_Stor_EST_var=currentVariable.localTimeSeriesGet("Ending_Stor_EST")
Ending_Stor_EST_var.setCurrentValue(currentRuntimestep, Ending_Stor_EST)

# Storage needed to get Bear back to EL( 751 or 750.7906)
if Ending_Stor_EST <Refill_level:
	Delta_St=Refill_level-Ending_Stor_EST
else:
	Delta_St=0

needed_flow=(Delta_St/1.98)+ DIV_needed

# Store for analysis/QC purposes
needed_flow_var=currentVariable.localTimeSeriesGet("needed_flow")
needed_flow_var.setCurrentValue(currentRuntimestep, needed_flow)
#--------------------------------------------------------------------------------------------------------------------------
# Pumping Capacity from Chattahoochee to Bear (13.9 mgd or 21.5 cfs)
pumping_capacity=21.5
#--------------------------------------------------------------------------------------------------------------------------
# Diversion is the lesser value of available chattahoochee flow, needed flow, and pumping capacity
Pump_IN=min(avail_Ch_fl,needed_flow,pumping_capacity)
```

```
currentVariable.setValue(currentRuntimestep, Pump_IN)

#####
##### 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

currentVariable.localTimeSeriesWriteAll()
```

PumptoGlades

```
#####
##### 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.

	currentVariable.localTimeSeriesNew("avail_Ch_fl")
	currentVariable.localTimeSeriesNew("needed_flow")
	return Constants.TRUE


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


# This state variable is used to compute the water pumped from Chattahoochee River to Glades Reservoir.
# Water is pumped when flow rate in the River just upstream of the pump station exceeds the annual
# 7Q10 (183.5 cfs), and when water level in Glades Reservoir is lower than 1180 ft MSL.

#inactive EL=1130.5 ft and at 1130 ft, storage is equal to 6962 ac-ft
IA_Stor = 6962.

ChattInflow = network.findJunction("PumpStation_IN").getLocalFlowTimeSeries("PumpStation_IN_LOC")
ChattInflow_Cur = ChattInflow.getCurrentValue(currentRuntimestep)
GladesSt = network.getTimeSeries("Reservoir","Glades", "Pool", "Stor")
GladesSt_Prev = GladesSt.getPreviousValue(currentRuntimestep)
Glades_Evap = network.getTimeSeries("Reservoir","Glades", "Pool", "Flow-EVAP")
Glades_Evap_Cur = Glades_Evap.getCurrentValue(currentRuntimestep)
GladesEl = network.getTimeSeries("Reservoir","Glades", "Pool", "Elev")
GladesEl_Prev = GladesEl.getPreviousValue(currentRuntimestep)
GladesIn_LOC = network.findJunction("Glades_IN").getLocalFlowTimeSeries("Glades_IN_LOC")
GladesIN_LOC_Cur = GladesIn_LOC.getCurrentValue(currentRuntimestep)

#computing available chatahoochee flow that could be diverted
ChattMIF=min(183.5,ChattInflow_Cur)

if (ChattInflow_Cur ) <= ChattMIF:
	avail_Ch_fl = 0
else:
	avail_Ch_fl = ChattInflow_Cur - ChattMIF

# Store for analysis/QC purposes
avail_Ch_fl_var=currentVariable.localTimeSeriesGet("avail_Ch_fl")
avail_Ch_fl_var.setCurrentValue(currentRuntimestep, avail_Ch_fl)

#computing Glades diversion
GladesDiv = 0

#Computing the minimum Release from Glades
Glades_min=min(4.6, GladesIN_LOC_Cur)

#Estimating the ending storage at current time step to determine needed flow to reach or maintain guide curve
Ending_Stor_EST = GladesSt_Prev + (GladesIN_LOC_Cur - GladesDiv - Glades_min- Glades_Evap_Cur)*(1.98)

#Storage deficit
Con_Zone = network.getTimeSeries("Reservoir","Glades", "Conservation", "Stor-ZONE")
Con_Zone_cur = Con_Zone.getCurrentValue(currentRuntimestep)

if Ending_Stor_EST < Con_Zone_cur:
```

```
        Stor_Def = Con_Zone_cur - Ending_Stor_EST
else:
        Stor_Def = 0

needed_flow = (Stor_Def/1.98)

# Store for analysis/QC purposes
needed_flow_var=currentVariable.localTimeSeriesGet("needed_flow")
needed_flow_var.setCurrentValue(currentRuntimestep, needed_flow)

#Pumping capacity from Pump Station to Glades is 60.3 cfs
pumping_capacity = 60.3

#To Glades diversion is the lesser value of available Chatt flow, needed flow, and pumping capacity
PumptoGlades = min(avail_Ch_fl,needed_flow,pumping_capacity)

currentVariable.setValue(currentRuntimestep, PumptoGlades)

#####
##### 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.localTimeSeriesWriteAll()
```

IV. Utility Scripts for Analyzing Results

Plotting and report script "buttons" are shown in Figure H.26.

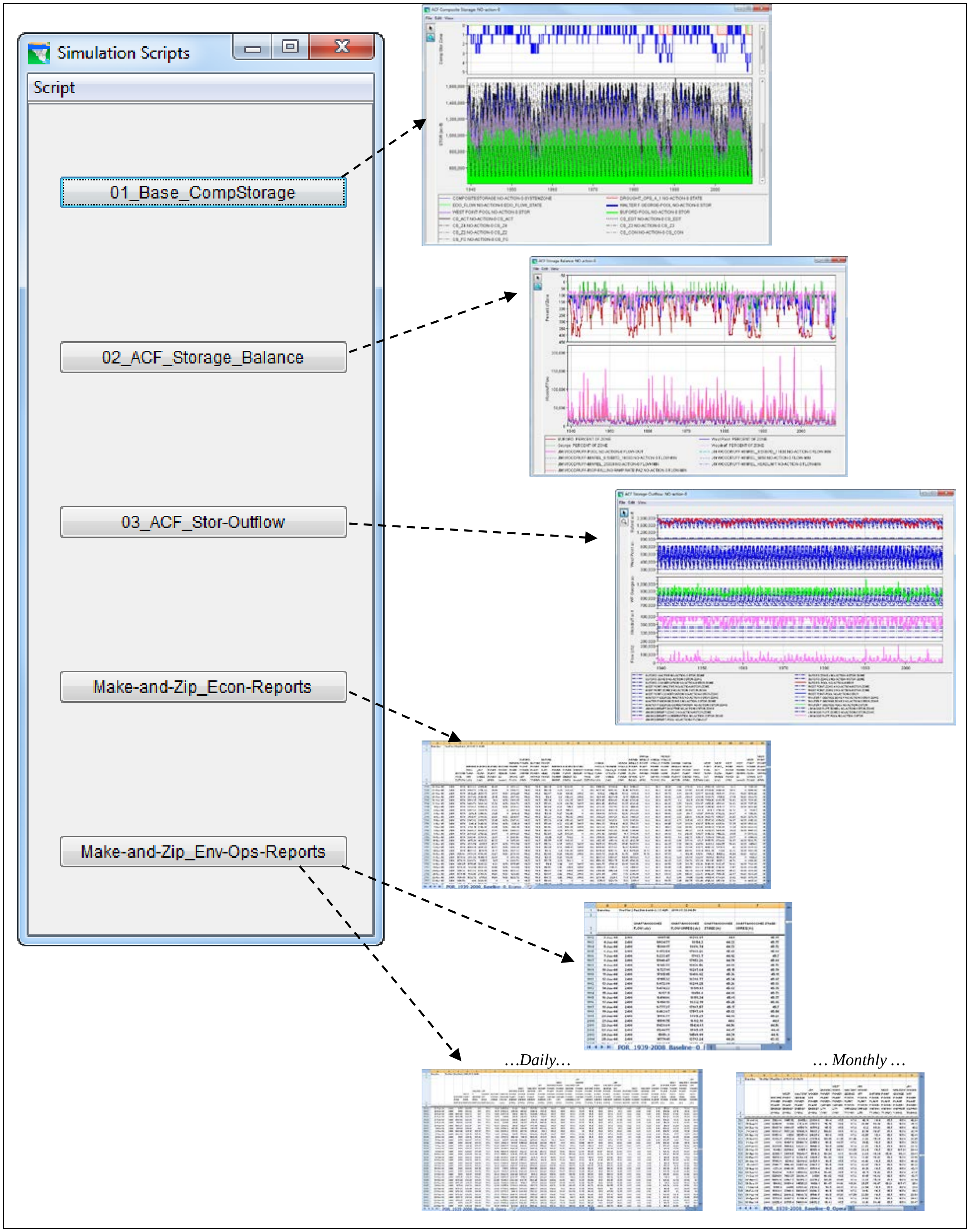

Figure H.26 Scripts in Simulation Module

A. Scripts for Plotting Results

Several scripts were developed for plotting simulation results for the ACF watershed. The following sections show the script editor, followed by a plot for the period-of-record results. Following the plot, the complete contents of the script are included in a table.

1. *Base_CompStorage*

Figure H.27 reflects the Script Editor for the plotting script named "01_Base_CompStorage".

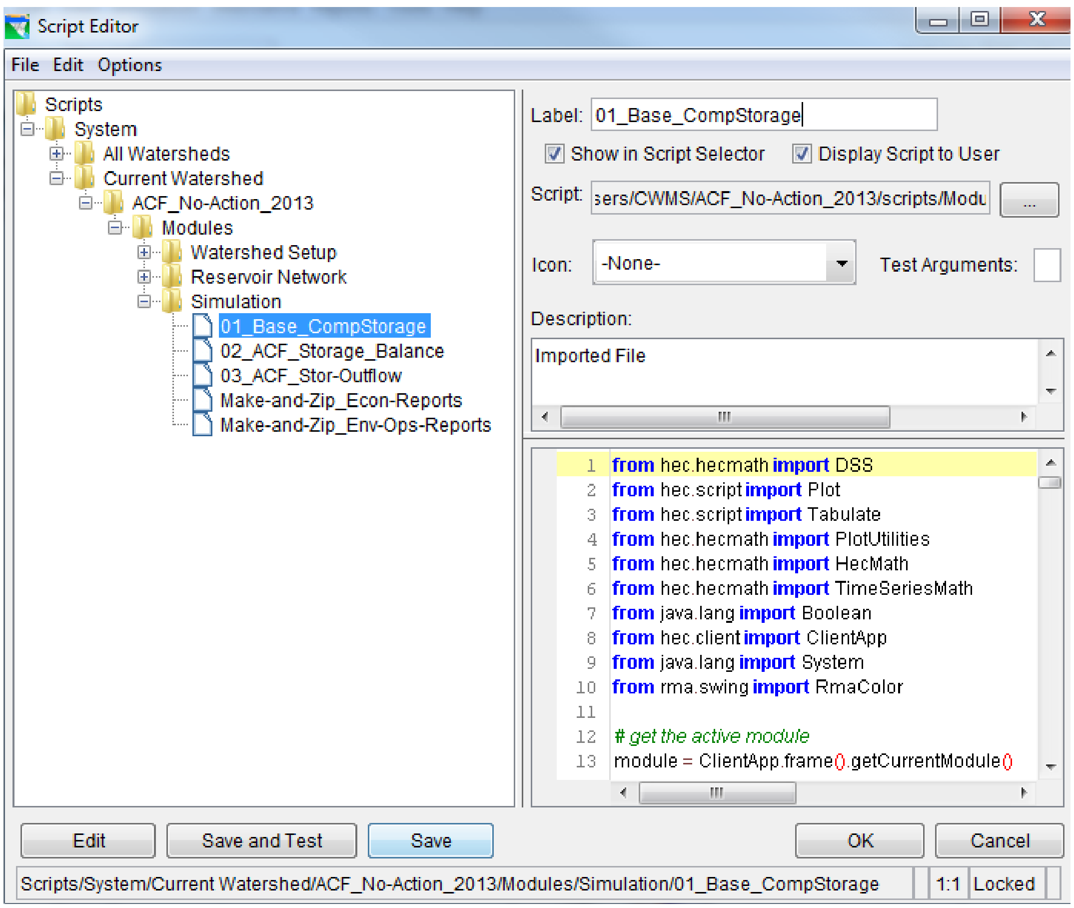

Figure H.27 Script Editor for "01_Base_CompStorage" Plot Script

Figure H.28 shows a plot generated by the script named "01_Base_CompStorage" for the "NOActionAx" alternative for the period of record simulation results.

Table H.13 contains the complete contents of the script named "01_Base_CompStorage".

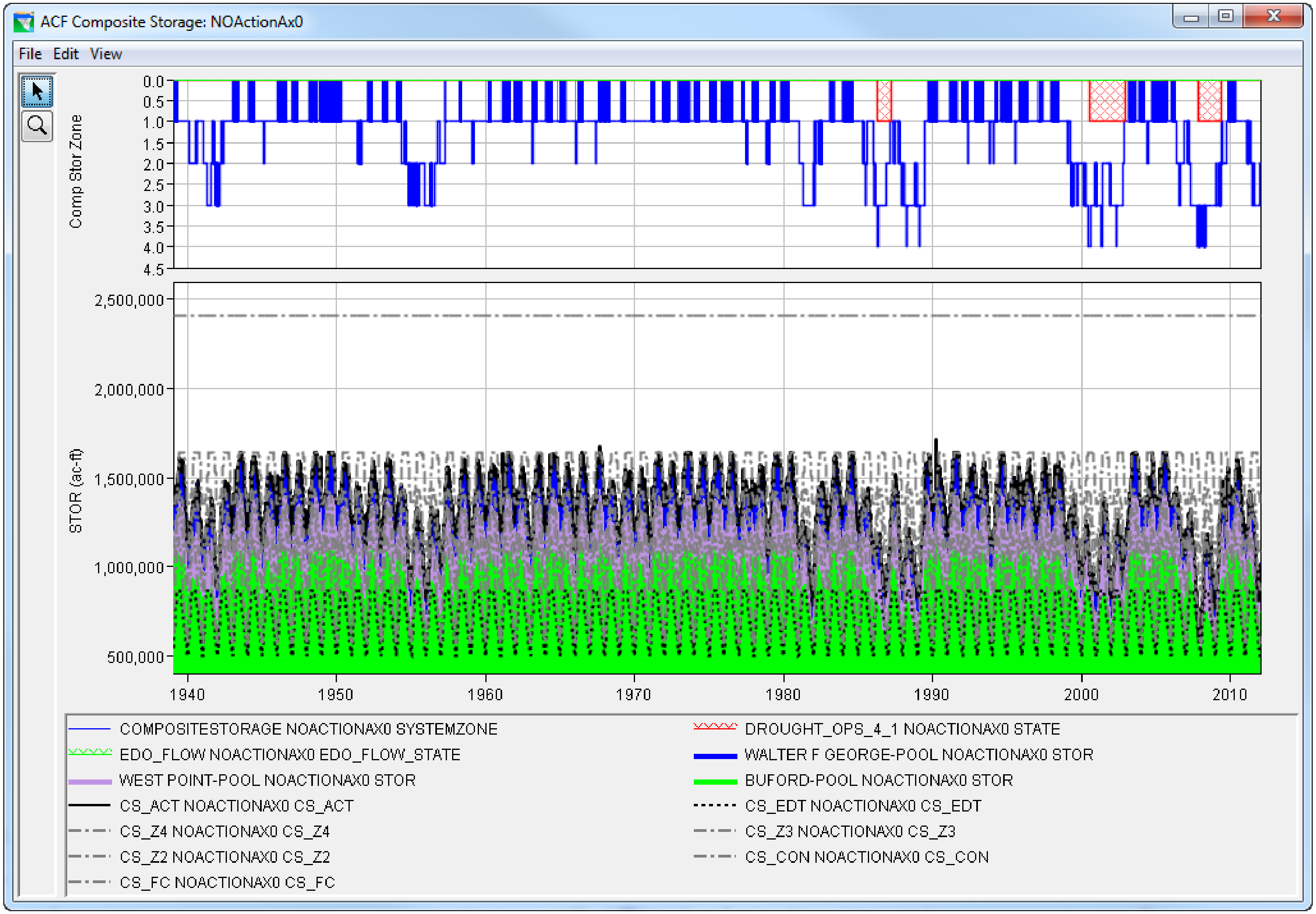

Figure H.28 Plot from "01_Base_CompStorage" Script Showing Period-of-Record "NOActionAx" Results

Table H.13 Contents of Plotting Script "01_Base_CompStorage"

```
# name=01_Base_CompStorage
# description=Imported File
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System
#from rma.swing import RmaColor

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
cmpCodeTS = dssfile.read("//COMPOSITESTORAGE/SYSTEMZONE/01JAN1939/1DAY/" + runname + "/")
cmpCodeTS.setType("PER-AVER")    # plot as stair step
dopCodeTS = dssfile.read("//DROUGHT_OPS_4_1/STATE/01JAN1939/1DAY/" + runname + "/")
dopCodeTS.setType("PER-AVER")   # plot as stair step
edoCodeTS=dssfile.read("//EDO_FLOW/EDO_FLOW_STATE/01JAN1939/1DAY/" + runname + "/")
edoCodeTS.setType("PER-AVER")   # plot as stair step
```

```
bufStorTS = dssfile.read("//BUFORD-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wptStorTS = dssfile.read("//WEST POINT-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wfgStorTS = dssfile.read("//WALTER F GEORGE-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wfgStorPlot = dssfile.read("//WALTER F GEORGE-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wptStorPlot = dssfile.read("//WEST POINT-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

wptStorPlot = wptStorPlot.add(bufStorTS)
wfgStorPlot = wfgStorPlot.add(bufStorTS).add(wptStorTS)

wptStorPlot = wptStorPlot.subtract(1166000)
#wptStorPlot = wptStorPlot.subtract(1856000)
wfgStorPlot = wfgStorPlot.subtract(1856000)
bufStorTS = bufStorTS.subtract(867600)

csactStorTS = dssfile.read("//CS_ACT/CS_ACT/01JAN1939/1DAY/" + runname + "/")
#csIAStorTS = dssfile.read("//CS_IA/CS_IA/01JAN1939/1DAY/" + runname + "/")
csedtStorTS = dssfile.read("//CS_EDT/CS_EDT/01JAN1939/1DAY/" + runname + "/")
csz4StorTS = dssfile.read("//CS_Z4/CS_Z4/01JAN1939/1DAY/" + runname + "/")
csz3StorTS = dssfile.read("//CS_Z3/CS_Z3/01JAN1939/1DAY/" + runname + "/")
csz2StorTS = dssfile.read("//CS_Z2/CS_Z2/01JAN1939/1DAY/" + runname + "/")
csConStorTS = dssfile.read("//CS_CON/CS_CON/01JAN1939/1DAY/" + runname + "/")
csFCStorTS = dssfile.read("//CS_FC/CS_FC/01JAN1939/1DAY/" + runname + "/")
csTODStorTS = dssfile.read("//CS_TOD/CS_TOD/01JAN1939/1DAY/" + runname + "/")

csactStorTS = csactStorTS.subtract(1856000)
#csIAStorTS = csIAStorTS.subtract(1856000)
csedtStorTS = csedtStorTS.subtract(1856000)
csz4StorTS = csz4StorTS.subtract(1856000)
csz3StorTS = csz3StorTS.subtract(1856000)
csz2StorTS = csz2StorTS.subtract(1856000)
csConStorTS = csConStorTS.subtract(1856000)
csFCStorTS = csFCStorTS.subtract(1856000)
csTODStorTS = csTODStorTS.subtract(1856000)

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
#rusPCTS.setLocation("RUSSELL")
#rusPCTS.setParameterPart("PERCENT OF CON")
#rusPCTS.setVersion("")
#rusPCTS.setUnits("%")

# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport(0.2)
vp1 = layout.addViewport(0.8)

# add the plot objects and initialize the plot
```

```
vp0.addCurve("Y1", cmpCodeTS.getData())
vp0.addCurve("Y1", dopCodeTS.getData())
vp0.addCurve("Y1", edoCodeTS.getData())

vp1.addCurve("Y1", wfgStorPlot.getData())
vp1.addCurve("Y1", wptStorPlot.getData())
vp1.addCurve("Y1", bufStorTS.getData())
vp1.addCurve("Y1", csactStorTS.getData())
#vp1.addCurve("Y1", csIAStorTS.getData())
vp1.addCurve("Y1", csedtStorTS.getData())
vp1.addCurve("Y1", csz4StorTS.getData())
vp1.addCurve("Y1", csz3StorTS.getData())
vp1.addCurve("Y1", csz2StorTS.getData())
vp1.addCurve("Y1", csConStorTS.getData())
vp1.addCurve("Y1", csFCStorTS.getData())
#vp1.addCurve("Y1", csTODStorTS.getData())

thePlot.setSize(1024,710)
thePlot.configurePlotLayout(layout)
thePlot.setLocation(0,0)
thePlot.showPlot()

vp0 = thePlot.getViewport(0)
uyAxis = vp0.getAxis("Y1")
uyAxis.setReversed(0)
uyAxis.setLabel("Comp Stor Zone")
uyAxis.setScaleLimits(0,5)
print "uyAxis.getMajorTic() before call to set() :", `uyAxis.getMajorTic()`
uyAxis.setMajorTicInterval(1.0)
print "uyAxis.getMajorTic() after set(1.0):", `uyAxis.getMajorTic()`

cmpCodeTSCurve = thePlot.getCurve(cmpCodeTS)
cmpCodeTSCurve.setLineColor("Blue")
cmpCodeTSCurve.setLineWidth(1.5)

dopCodeTSCurve = thePlot.getCurve(dopCodeTS)
dopCodeTSCurve.setLineColor("Red")
dopCodeTSCurve.setLineWidth(1.5)
dopCodeTSCurve.setFillType("Above")
dopCodeTSCurve.setFillColor("Red")
dopCodeTSCurve.setFillPattern("Diagonal Cross")

edoCodeTSCurve = thePlot.getCurve(edoCodeTS)
edoCodeTSCurve.setLineColor("Green")
edoCodeTSCurve.setLineWidth(1.0)
edoCodeTSCurve.setFillType("Above")
edoCodeTSCurve.setFillColor("Green")
edoCodeTSCurve.setFillPattern("Diagonal Cross")

wfgStorPlotCurve = thePlot.getCurve(wfgStorPlot)
```

```
wfgStorPlotCurve.setLineColor("Blue")
wfgStorPlotCurve.setLineWidth(1)
wfgStorPlotCurve.setFillType("Below")
wfgStorPlotCurve.setFillColor("Blue")
wfgStorPlotCurve.setFillPattern("Solid")

#darklavender = Color(191, 148, 228)
wptStorPlotCurve = thePlot.getCurve(wptStorPlot)
#wptStorPlotCurve.setLineColor(darklavender)
wptStorPlotCurve.setLineColor("191,148,228")
wptStorPlotCurve.setLineWidth(1)
wptStorPlotCurve.setFillType("Below")
wptStorPlotCurve.setFillColor( "pink" )
#wptStorPlotCurve.setFillColor( darklavender )
wptStorPlotCurve.setFillColor("191,148,228")
wptStorPlotCurve.setFillPattern("Solid")

bufStorTSCurve = thePlot.getCurve(bufStorTS)
bufStorTSCurve.setLineColor("Green")
bufStorTSCurve.setLineWidth(1)
bufStorTSCurve.setFillType("Below")
bufStorTSCurve.setFillColor("Green")
bufStorTSCurve.setFillPattern("Solid")

csactStorTSCurve = thePlot.getCurve(csactStorTS)
csactStorTSCurve.setLineColor("Black")
csactStorTSCurve.setLineWidth(2)

#csIAStorTSCurve = thePlot.getCurve(csIAStorTS)
#csIAStorTSCurve.setLineColor("Black")
#csIAStorTSCurve.setLineWidth(1)

csedtStorTSCurve = thePlot.getCurve(csedtStorTS)
csedtStorTSCurve.setLineColor("Black")
csedtStorTSCurve.setLineWidth(2)
csedtStorTSCurve.setLineStyle("Dot")

csz4StorTSCurve = thePlot.getCurve(csz4StorTS)
csz4StorTSCurve.setLineColor("Gray")
csz4StorTSCurve.setLineWidth(2)
csz4StorTSCurve.setLineStyle("Dash Dot")

csz3StorTSCurve = thePlot.getCurve(csz3StorTS)
csz3StorTSCurve.setLineColor("Gray")
csz3StorTSCurve.setLineWidth(2)
csz3StorTSCurve.setLineStyle("Dash Dot")

csz2StorTSCurve = thePlot.getCurve(csz2StorTS)
csz2StorTSCurve.setLineColor("Gray")
csz2StorTSCurve.setLineWidth(2)
csz2StorTSCurve.setLineStyle("Dash Dot")
```

```
csConStorTSCurve = thePlot.getCurve(csConStorTS)
csConStorTSCurve.setLineColor("Gray")
csConStorTSCurve.setLineWidth(2)
csConStorTSCurve.setLineStyle("Dash Dot")

csFCStorTSCurve = thePlot.getCurve(csFCStorTS)
csFCStorTSCurve.setLineColor("Gray")
csFCStorTSCurve.setLineWidth(2)
csFCStorTSCurve.setLineStyle("Dash Dot")

#csTODStorTSCurve = thePlot.getCurve(csTODStorTS)
#csTODStorTSCurve.setLineColor("Black")
#csTODStorTSCurve.setLineWidth(1)

vp1a = thePlot.getViewport(1)
lyAxis1 = vp1a.getAxis("Y1")
lyAxis1.setScaleLimits(400000,1800000)
thePlot.setTitle("ACF Composite Storage: " + runname)
```

2. *ACF_Storage_Balance*

Figure H.29 reflects the Script Editor for the plotting script named "02_ACF_Storage_Balance".

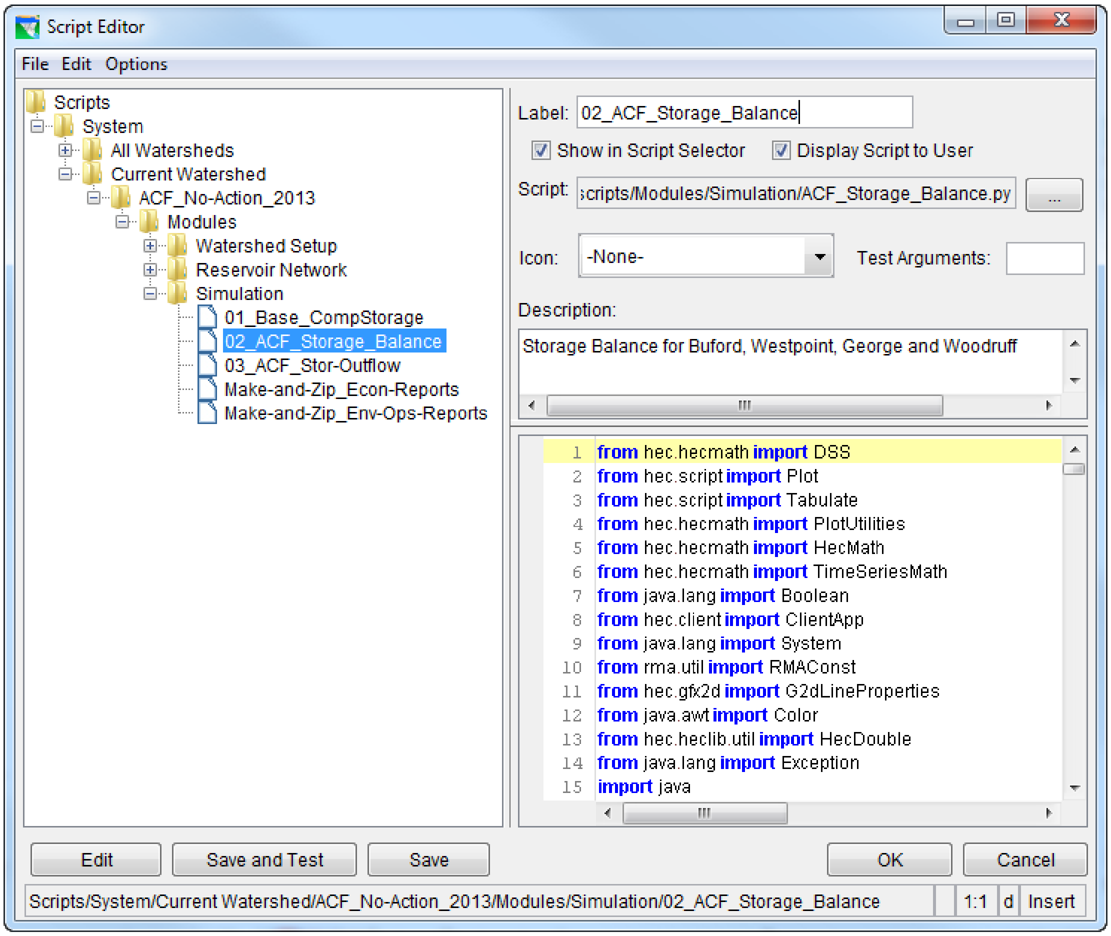

Figure H.29 Script Editor for "02_ACF_Storage_Balance" Plot Script

Figure H.30 shows a plot generated by the script named "02_ACF_Storage_Balance"for the "NOActionAx" alternative for the period of record simulation results.

Table H.14 contains the complete contents of the script named "02_ACF_Storage_Balance".

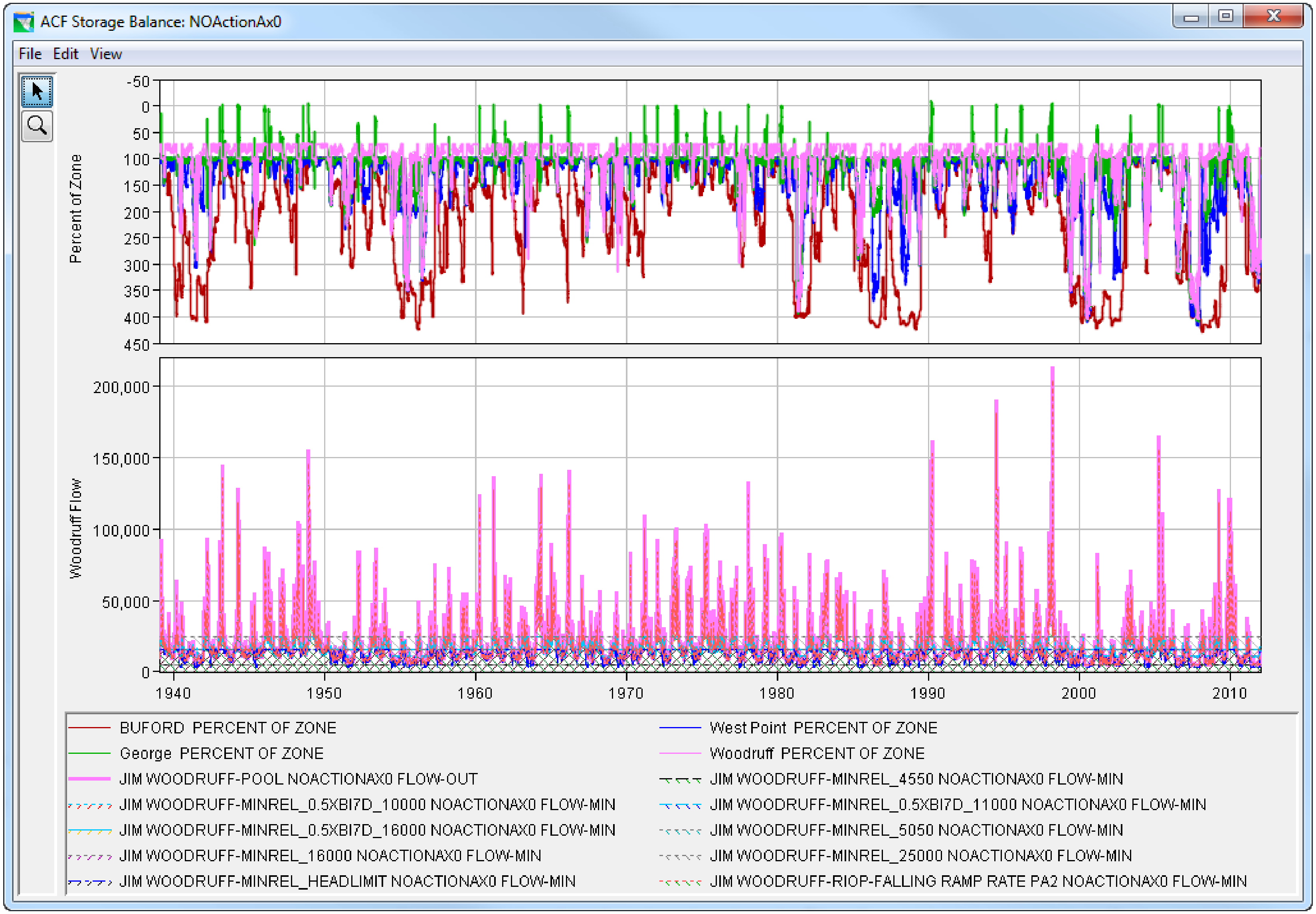

Figure H.30 Plot from “02_ACF_Storage_Balance” Script Showing Period-of-Record “NOActionAx” Results

Table H.14 Contents of Plotting Script "02_ACF_Storage_Balance"

```
# name=02_ACF_Storage_Balance
# description=Storage Balance for Buford, Westpoint, George and Woodruff
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System
from rma.util import RMAConst
from hec.gfx2d import G2dLineProperties
from java.awt import Color
from hec.heclib.util import HecDouble
from java.lang import Exception
import java


###### function to compute percent of zone storage
def calcPercentZoneStor(baseTS, z0TS, z1TS, offset):

	tmpts = baseTS.subtract(z0TS).divide(z1TS.subtract(z0TS)).multiply(100).screenWithMaxMin(0,100,99999,True,-901,"R")
	tmpts = tmpts.replaceSpecificValues(HecDouble(-901),HecDouble(HecMath.UNDEFINED))
	try:
		tmpts.checkTimeSeries(tmpts.getContainer())
	except java.lang.Exception:
		return tmpts

	return tmpts.add(offset)

###### function to compute percent of zone storage
def mergeTS(z0TS, z1TS):


#	 print "Attempting mergeTS"

	try:
		z0TS.checkTimeSeries(z0TS.getContainer())
	except java.lang.Exception:
#		print "Caught hec.hecmath.HecMathException on z0TS"
		return z1TS

	try:
		z1TS.checkTimeSeries(z1TS.getContainer())
```

```
        except java.lang.Exception:
#               print "Caught hec.hecmath.HecMathException on z1TS"
                return z0TS

        tmpts = z0TS.mergeTimeSeries(z1TS)
        return tmpts


###### main routine

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
bufStorTS = dssfile.read("//BUFORD-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wesStorTS = dssfile.read("//WEST POINT-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
geoStorTS = dssfile.read("//WALTER F GEORGE-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wooStorTS = dssfile.read("//JIM WOODRUFF-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

wooReleaseTS = dssfile.read("//JIM WOODRUFF-POOL/FLOW-OUT/01JAN1939/1DAY/" + runname + "/")
wooMR_4kTS = dssfile.read("//JIM WOODRUFF-MINREL_4550/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooBI_10kTS = dssfile.read("//JIM WOODRUFF-MINREL_0.5XBI7D_10000/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooBI_11kTS = dssfile.read("//JIM WOODRUFF-MINREL_0.5XBI7D_11000/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooBI_16kTS = dssfile.read("//JIM WOODRUFF-MINREL_0.5XBI7D_16000/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooMR_5kTS = dssfile.read("//JIM WOODRUFF-MINREL_5050/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooMR_16kTS = dssfile.read("//JIM WOODRUFF-MINREL_16000/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooMR_25kTS = dssfile.read("//JIM WOODRUFF-MINREL_25000/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooMR_HeadLimitTS = dssfile.read("//JIM WOODRUFF-MINREL_HEADLIMIT/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
wooMR_RampRateTS = dssfile.read("//JIM WOODRUFF-RIOP-FALLING RAMP RATE PA2/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
```

```
bufStorZ0TS = dssfile.read("//BUFORD-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
#bufStorZ1TS = dssfile.read("//BUFORD-BUFFER/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ1TS = dssfile.read("//BUFORD-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ2TS = dssfile.read("//BUFORD-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ3TS = dssfile.read("//BUFORD-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ4TS = dssfile.read("//BUFORD-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ5TS = dssfile.read("//BUFORD-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ6TS = dssfile.read("//BUFORD-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

wesStorZ0TS = dssfile.read("//WEST POINT-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ1TS = dssfile.read("//WEST POINT-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ2TS = dssfile.read("//WEST POINT-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ3TS = dssfile.read("//WEST POINT-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ4TS = dssfile.read("//WEST POINT-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ5TS = dssfile.read("//WEST POINT-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ6TS = dssfile.read("//WEST POINT-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

geoStorZ0TS = dssfile.read("//WALTER F GEORGE-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ1TS = dssfile.read("//WALTER F GEORGE-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ2TS = dssfile.read("//WALTER F GEORGE-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ3TS = dssfile.read("//WALTER F GEORGE-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ4TS = dssfile.read("//WALTER F GEORGE-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ5TS = dssfile.read("//WALTER F GEORGE-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ6TS = dssfile.read("//WALTER F GEORGE-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

wooStorZ0TS = dssfile.read("//JIM WOODRUFF-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ1TS = dssfile.read("//JIM WOODRUFF-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ2TS = dssfile.read("//JIM WOODRUFF-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ3TS = dssfile.read("//JIM WOODRUFF-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ4TS = dssfile.read("//JIM WOODRUFF-ZONE 1/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
# wooStorZ4TS = dssfile.read("//JIM WOODRUFF-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ5TS = dssfile.read("//JIM WOODRUFF-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ6TS = dssfile.read("//JIM WOODRUFF-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# calculate the percent of zone time series using HecMath routines
bufPZ0TS = calcPercentZoneStor(bufStorTS, bufStorZ1TS, bufStorZ0TS, 400)
bufPZ1TS = calcPercentZoneStor(bufStorTS, bufStorZ2TS, bufStorZ1TS, 300)
bufPZ2TS = calcPercentZoneStor(bufStorTS, bufStorZ3TS, bufStorZ2TS, 200)
bufPZ3TS = calcPercentZoneStor(bufStorTS, bufStorZ4TS, bufStorZ3TS, 100)
bufPZ4TS = calcPercentZoneStor(bufStorTS, bufStorZ5TS, bufStorZ4TS, 0)
bufPZ5TS = calcPercentZoneStor(bufStorTS, bufStorZ6TS, bufStorZ5TS, -100)

bufPZTS = mergeTS(bufPZ0TS, bufPZ1TS)
bufPZTS = mergeTS(bufPZTS,  bufPZ2TS)
bufPZTS = mergeTS(bufPZTS,  bufPZ3TS)
bufPZTS = mergeTS(bufPZTS,  bufPZ4TS)
bufPZTS = mergeTS(bufPZTS,  bufPZ5TS)


wesPZ0TS = calcPercentZoneStor(wesStorTS, wesStorZ1TS, wesStorZ0TS, 400)
```

```
wesPZ1TS = calcPercentZoneStor(wesStorTS, wesStorZ2TS, wesStorZ1TS, 300)
wesPZ2TS = calcPercentZoneStor(wesStorTS, wesStorZ3TS, wesStorZ2TS, 200)
wesPZ3TS = calcPercentZoneStor(wesStorTS, wesStorZ4TS, wesStorZ3TS, 100)
wesPZ4TS = calcPercentZoneStor(wesStorTS, wesStorZ5TS, wesStorZ4TS, 000)
wesPZ5TS = calcPercentZoneStor(wesStorTS, wesStorZ6TS, wesStorZ5TS, -100)

wesPZTS = mergeTS(wesPZ0TS, wesPZ1TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ2TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ3TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ4TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ5TS)

geoPZ0TS = calcPercentZoneStor(geoStorTS, geoStorZ1TS, geoStorZ0TS, 400)
geoPZ1TS = calcPercentZoneStor(geoStorTS, geoStorZ2TS, geoStorZ1TS, 300)
geoPZ2TS = calcPercentZoneStor(geoStorTS, geoStorZ3TS, geoStorZ2TS, 200)
geoPZ3TS = calcPercentZoneStor(geoStorTS, geoStorZ4TS, geoStorZ3TS, 100)
geoPZ4TS = calcPercentZoneStor(geoStorTS, geoStorZ5TS, geoStorZ4TS, 0)
geoPZ5TS = calcPercentZoneStor(geoStorTS, geoStorZ6TS, geoStorZ5TS, -100)

geoPZTS = mergeTS(geoPZ0TS, geoPZ1TS)
geoPZTS = mergeTS(geoPZTS,  geoPZ2TS)
geoPZTS = mergeTS(geoPZTS,  geoPZ3TS)
geoPZTS = mergeTS(geoPZTS,  geoPZ4TS)
geoPZTS = mergeTS(geoPZTS,  geoPZ5TS)

wooPZ0TS = calcPercentZoneStor(wooStorTS, wooStorZ1TS, wooStorZ0TS, 400)
wooPZ1TS = calcPercentZoneStor(wooStorTS, wooStorZ2TS, wooStorZ1TS, 300)
wooPZ2TS = calcPercentZoneStor(wooStorTS, wooStorZ3TS, wooStorZ2TS, 200)
wooPZ3TS = calcPercentZoneStor(wooStorTS, wooStorZ4TS, wooStorZ3TS, 100)
wooPZ4TS = calcPercentZoneStor(wooStorTS, wooStorZ5TS, wooStorZ4TS, 000)
wooPZ5TS = calcPercentZoneStor(wooStorTS, wooStorZ6TS, wooStorZ5TS, -100)

wooPZTS = mergeTS(wooPZ0TS, wooPZ1TS)
wooPZTS = mergeTS(wooPZTS,  wooPZ2TS)
wooPZTS = mergeTS(wooPZTS,  wooPZ3TS)
wooPZTS = mergeTS(wooPZTS,  wooPZ4TS)
wooPZTS = mergeTS(wooPZTS,  wooPZ5TS)

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
bufPZTS.setLocation("BUFORD")
bufPZTS.setParameterPart("PERCENT OF ZONE")
bufPZTS.setVersion("")
bufPZTS.setUnits("%")

wesPZTS.setLocation("West Point")
wesPZTS.setParameterPart("PERCENT OF ZONE")
wesPZTS.setVersion("")
wesPZTS.setUnits("%")
```

```
geoPZTS.setLocation("George")
geoPZTS.setParameterPart("PERCENT OF ZONE")
geoPZTS.setVersion("")
geoPZTS.setUnits("%")

wooPZTS.setLocation("Woodruff")
wooPZTS.setParameterPart("PERCENT OF ZONE")
wooPZTS.setVersion("")
wooPZTS.setUnits("%")

# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport(0.40)
vp1 = layout.addViewport(0.60)

vp0.addCurve("Y1", bufPZTS.getData())
vp0.addCurve("Y1", wesPZTS.getData())
vp0.addCurve("Y1", geoPZTS.getData())
vp0.addCurve("Y1", wooPZTS.getData())

vp1.addCurve("Y1", wooReleaseTS.getData())
vp1.addCurve("Y1", wooMR_4kTS.getData())
vp1.addCurve("Y1", wooBI_10kTS.getData())
vp1.addCurve("Y1", wooBI_11kTS.getData())
vp1.addCurve("Y1", wooBI_16kTS.getData())
vp1.addCurve("Y1", wooMR_5kTS.getData())
vp1.addCurve("Y1", wooMR_16kTS.getData())
vp1.addCurve("Y1", wooMR_25kTS.getData())
vp1.addCurve("Y1", wooMR_HeadLimitTS.getData())
vp1.addCurve("Y1", wooMR_RampRateTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

vp0 = thePlot.getViewport(0)
vp1 = thePlot.getViewport(1)
uyAxis = vp0.getAxis("Y1")
uyAxis.setReversed(0)
lyAxis = vp1.getAxis("Y1")

uyAxis.setLabel("Percent of Zone")
lyAxis.setLabel("Woodruff Flow")

bufPZTSCurve = thePlot.getCurve(bufPZTS)
bufPZTSCurve.setLineColor("DarkRed")
bufPZTSCurve.setLineWidth(1.5)
```

```
wesPZTSCurve = thePlot.getCurve(wesPZTS)
wesPZTSCurve.setLineColor("Blue")
wesPZTSCurve.setLineWidth(1.5)

geoPZTSCurve = thePlot.getCurve(geoPZTS)
geoPZTSCurve.setLineColor("DarkGreen")
geoPZTSCurve.setLineWidth(1.5)

wooPZTSCurve = thePlot.getCurve(wooPZTS)
wooPZTSCurve.setLineColor("LightMagenta")
wooPZTSCurve.setLineWidth(1.5)

wooReleaseTSCurve = thePlot.getCurve(wooReleaseTS)
wooReleaseTSCurve.setLineColor("LightMagenta")
wooReleaseTSCurve.setLineWidth(3)

wooEDO_4500TSCurve = thePlot.getCurve(wooMR_4kTS)
wooEDO_4500TSCurve.setLineColor("Black")
wooEDO_4500TSCurve.setLineWidth(1)
wooEDO_4500TSCurve.setLineStyle("Dash")

wooBI_10kTSCurve = thePlot.getCurve(wooBI_10kTS)
wooBI_10kTSCurve.setLineColor("LightBlue")
wooBI_10kTSCurve.setLineWidth(1)
wooBI_10kTSCurve.setLineStyle("Dot")

wooBI_11kTSCurve = thePlot.getCurve(wooBI_11kTS)
wooBI_11kTSCurve.setLineColor("LightBlue")
wooBI_11kTSCurve.setLineWidth(1)
#wooBI_11kTSCurve.setLineStyle("Dot")

wooBI_16kTSCurve = thePlot.getCurve(wooBI_16kTS)
wooBI_16kTSCurve.setLineColor("LightBlue")
wooBI_16kTSCurve.setLineWidth(1)
#wooBI_16kTSCurve.setLineStyle("Dot")

wooMR_5kTSCurve = thePlot.getCurve(wooMR_5kTS)
wooMR_5kTSCurve.setLineColor("Gray")
wooMR_5kTSCurve.setLineWidth(1)
wooMR_5kTSCurve.setLineStyle("Dot")

wooMR_16kTSCurve = thePlot.getCurve(wooMR_16kTS)
wooMR_16kTSCurve.setLineColor("Gray")
wooMR_16kTSCurve.setLineWidth(1)
wooMR_16kTSCurve.setLineStyle("Dot")

wooMR_25kTSCurve = thePlot.getCurve(wooMR_25kTS)
wooMR_25kTSCurve.setLineColor("Gray")
wooMR_25kTSCurve.setLineWidth(1)
wooMR_25kTSCurve.setLineStyle("Dot")
```

```
wooMR_HeadLimitTSCurve = thePlot.getCurve(wooMR_HeadLimitTS)
wooMR_HeadLimitTSCurve.setLineColor("Blue")
wooMR_HeadLimitTSCurve.setLineWidth(1)
wooMR_HeadLimitTSCurve.setLineStyle("Dash Dot")

wooMR_RampRateTSCurve = thePlot.getCurve(wooMR_RampRateTS)
wooMR_RampRateTSCurve.setLineColor("LightRed")
wooMR_RampRateTSCurve.setLineWidth(1)
wooMR_RampRateTSCurve.setLineStyle("Dot")
#


# set plot title with run name
thePlot.setTitle("ACF Storage Balance: " + runname)
```

3. *ACF_Stor-Outflow*

Figure H.31 reflects the Script Editor for the plotting script named "03_ACF_Stor-Outflow".

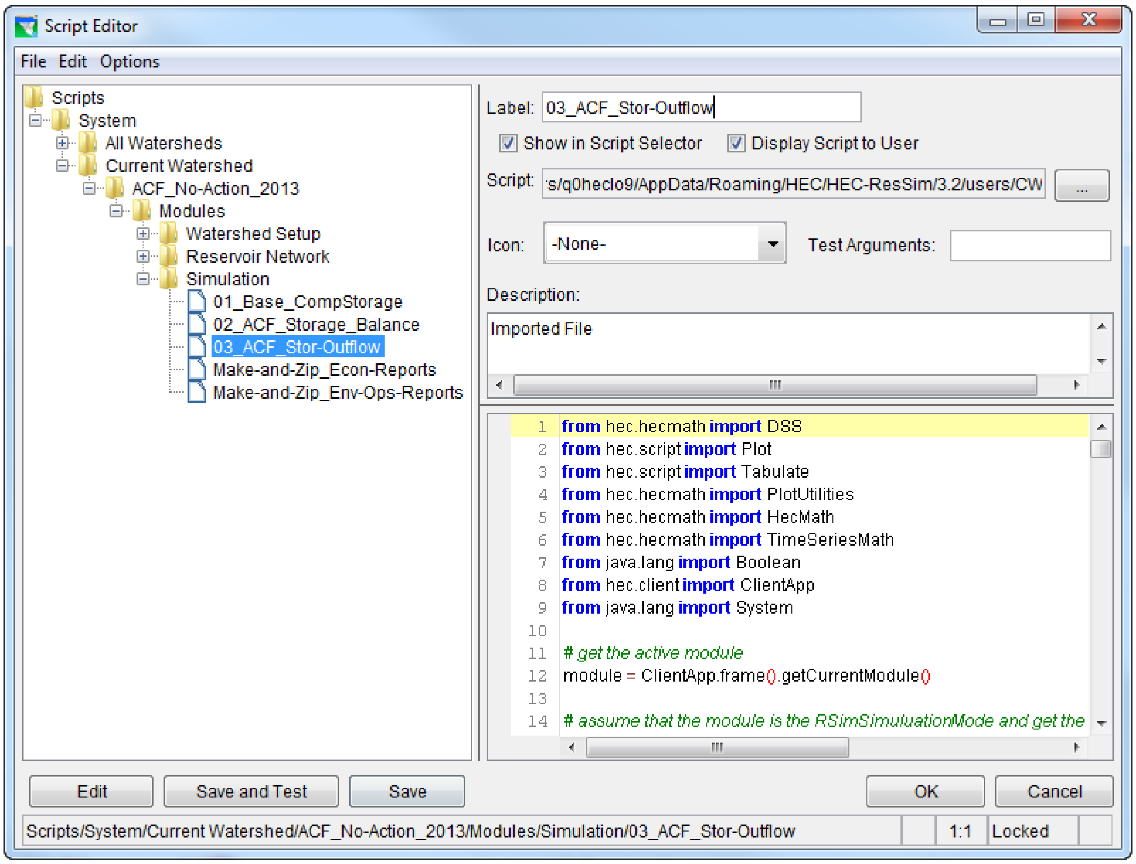

Figure H.31 Script Editor for "03_ACF_Stor-Outflow" Plot Script

Figure H.32 shows a plot generated by the script named "03_ACF_Stor-Outflow" for the "NOActionAx" alternative for the period of record simulation results.

Table H.15 contains the complete contents of the script named "03_ACF_Stor-Outflow".

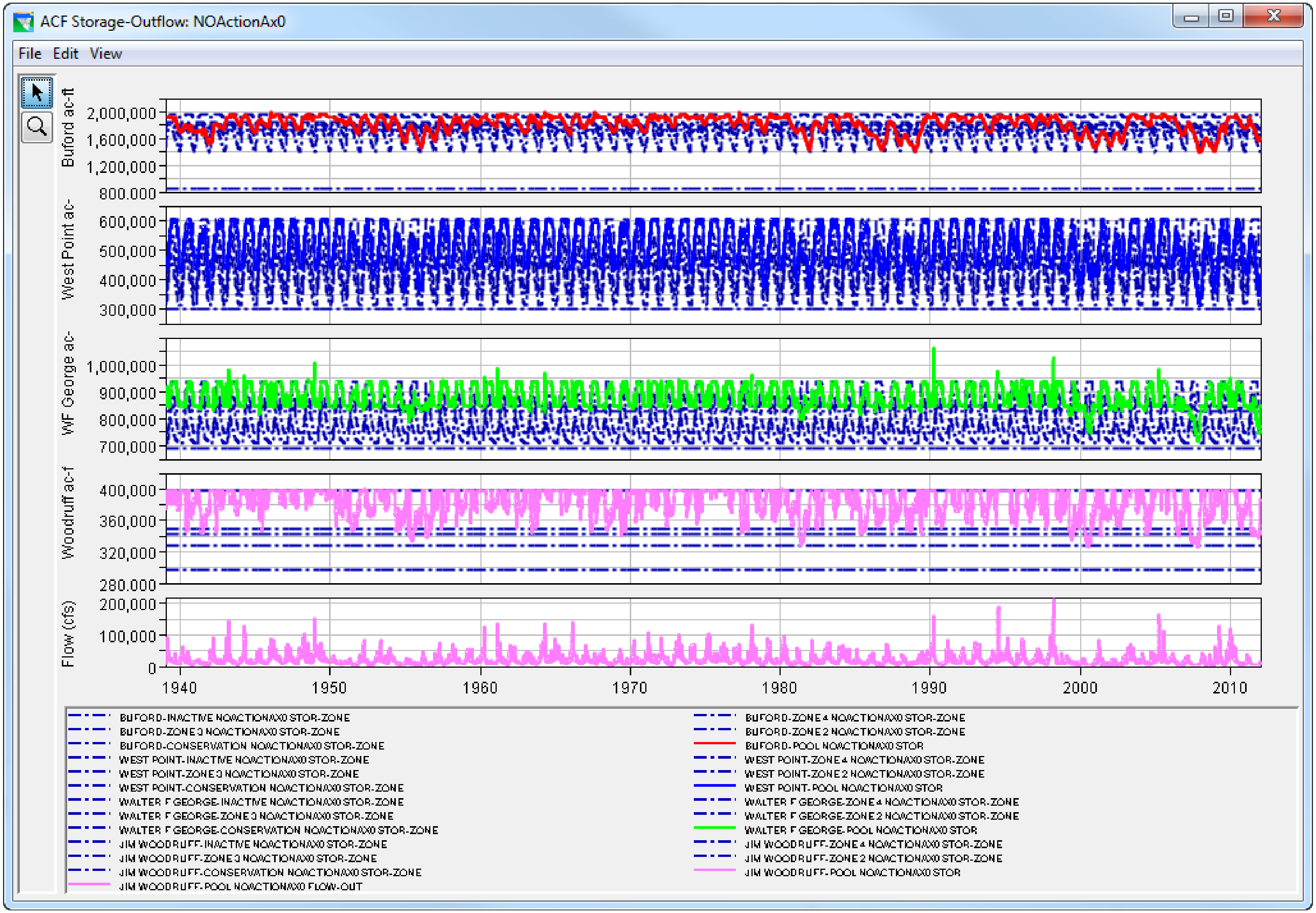

Figure H.32 Plot from "03_ACF_Stor-Outflow" Script Showing Period-of-Record "NOActionAx" Results

Table H.15 Contents of Plotting Script "03_ACF_Stor-Outflow"

```
# name=03_ACF_Stor-Outflow
# description=Imported File
# displaytouser=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
       noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
bufStorTS = dssfile.read("//BUFORD-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wesStorTS = dssfile.read("//WEST POINT-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
geoStorTS = dssfile.read("//WALTER F GEORGE-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wooStorTS = dssfile.read("//JIM WOODRUFF-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

wooReleaseTS = dssfile.read("//JIM WOODRUFF-POOL/FLOW-OUT/01JAN1939/1DAY/" + runname + "/")

bufStorZ0TS = dssfile.read("//BUFORD-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
#bufStorZ1TS = dssfile.read("//BUFORD-BUFFER/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
```

```
bufStorZ1TS = dssfile.read("//BUFORD-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ2TS = dssfile.read("//BUFORD-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ3TS = dssfile.read("//BUFORD-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ4TS = dssfile.read("//BUFORD-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ5TS = dssfile.read("//BUFORD-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
bufStorZ6TS = dssfile.read("//BUFORD-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

wesStorZ0TS = dssfile.read("//WEST POINT-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ1TS = dssfile.read("//WEST POINT-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ2TS = dssfile.read("//WEST POINT-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ3TS = dssfile.read("//WEST POINT-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ4TS = dssfile.read("//WEST POINT-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ5TS = dssfile.read("//WEST POINT-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ6TS = dssfile.read("//WEST POINT-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

geoStorZ0TS = dssfile.read("//WALTER F GEORGE-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ1TS = dssfile.read("//WALTER F GEORGE-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ2TS = dssfile.read("//WALTER F GEORGE-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ3TS = dssfile.read("//WALTER F GEORGE-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ4TS = dssfile.read("//WALTER F GEORGE-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ5TS = dssfile.read("//WALTER F GEORGE-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
geoStorZ6TS = dssfile.read("//WALTER F GEORGE-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

wooStorZ0TS = dssfile.read("//JIM WOODRUFF-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ1TS = dssfile.read("//JIM WOODRUFF-ZONE 4/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ2TS = dssfile.read("//JIM WOODRUFF-ZONE 3/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ3TS = dssfile.read("//JIM WOODRUFF-ZONE 2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ4TS = dssfile.read("//JIM WOODRUFF-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ5TS = dssfile.read("//JIM WOODRUFF-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wooStorZ6TS = dssfile.read("//JIM WOODRUFF-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
#rusPCTS.setLocation("RUSSELL")
#rusPCTS.setParameterPart("PERCENT OF CON")
#rusPCTS.setVersion("")
#rusPCTS.setUnits("%")


# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport(0.2)
vp0.setAxisName("Y1", "BUF")
vp0.setAxisLabel("Y1", "Buford ac-ft")
vp1 = layout.addViewport(0.2)
vp1.setAxisName("Y1", "WPT")
vp1.setAxisLabel("Y1", "West Point ac-ft")
```

```
vp2 = layout.addViewport(0.2)
vp2.setAxisName("Y1", "WFG")
vp2.setAxisLabel("Y1", "WF George ac-ft")
vp3 = layout.addViewport(0.2)
vp3.setAxisName("Y1", "WOO")
vp3.setAxisLabel("Y1", "Woodruff ac-ft")
vp4 = layout.addViewport(0.2)

vp0.addCurve("Y1", bufStorZ0TS.getData())
vp0.addCurve("Y1", bufStorZ1TS.getData())
vp0.addCurve("Y1", bufStorZ2TS.getData())
vp0.addCurve("Y1", bufStorZ3TS.getData())
vp0.addCurve("Y1", bufStorZ4TS.getData())
vp0.addCurve("Y1", bufStorTS.getData())

vp1.addCurve("Y1", wesStorZ0TS.getData())
vp1.addCurve("Y1", wesStorZ1TS.getData())
vp1.addCurve("Y1", wesStorZ2TS.getData())
vp1.addCurve("Y1", wesStorZ3TS.getData())
vp1.addCurve("Y1", wesStorZ4TS.getData())
vp1.addCurve("Y1", wesStorTS.getData())

vp2.addCurve("Y1", geoStorZ0TS.getData())
vp2.addCurve("Y1", geoStorZ1TS.getData())
vp2.addCurve("Y1", geoStorZ2TS.getData())
vp2.addCurve("Y1", geoStorZ3TS.getData())
vp2.addCurve("Y1", geoStorZ4TS.getData())
vp2.addCurve("Y1", geoStorTS.getData())

vp3.addCurve("Y1", wooStorZ0TS.getData())
vp3.addCurve("Y1", wooStorZ1TS.getData())
vp3.addCurve("Y1", wooStorZ2TS.getData())
vp3.addCurve("Y1", wooStorZ3TS.getData())
vp3.addCurve("Y1", wooStorZ4TS.getData())
vp3.addCurve("Y1", wooStorTS.getData())

vp4.addCurve("Y1", wooReleaseTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

bufStorTSCurve = thePlot.getCurve(bufStorTS)
bufStorTSCurve.setLineColor("Red")
bufStorTSCurve.setLineWidth(2)

wesStorTSCurve = thePlot.getCurve(wesStorTS)
wesStorTSCurve.setLineColor("Blue")
wesStorTSCurve.setLineWidth(2)
```

```
geoStorTSCurve = thePlot.getCurve(geoStorTS)
geoStorTSCurve.setLineColor("Green")
geoStorTSCurve.setLineWidth(2)

wooStorTSCurve = thePlot.getCurve(wooStorTS)
wooStorTSCurve.setLineColor("LightMagenta")
wooStorTSCurve.setLineWidth(2)

wooReleaseTSCurve = thePlot.getCurve(wooReleaseTS)
wooReleaseTSCurve.setLineColor("LightMagenta")
wooReleaseTSCurve.setLineWidth(2)

# set plot title with run name
thePlot.setTitle("ACF Storage-Outflow: " + runname)

vp0a = thePlot.getViewport(0)
lyAxis0 = vp0a.getAxis("Y1")
lyAxis0.setScaleLimits(1200000,2200000)
vp1a = thePlot.getViewport(1)
lyAxis1 = vp1a.getAxis("Y1")
lyAxis1.setScaleLimits(200000,700000)
vp2a = thePlot.getViewport(2)
lyAxis2 = vp2a.getAxis("Y1")
lyAxis2.setScaleLimits(650000,1000000)
vp3a = thePlot.getViewport(3)
lyAxis3 = vp3a.getAxis("Y1")
lyAxis3.setScaleLimits(330000,420000)
```

B. Reports

Four report templates and two report generation scripts were developed to create "comma-separated-value" (csv) files to tabulate results for the ACF watershed simulations. Figure H.33 illustrates the "reports" folder location within the watershed tree, as well as the contents of the folder. The four report templates named "Economics", "Environmental", "Operation-Daily", and "Operation-Monthly" are used by the report generation utility scripts named "Make-and-Zip_Econ-Reports" and "Make-and-Zip_Env-Ops-Reports". The zipped files were generated by the report generation scripts. The naming convention of the zipped files includes the name of the report template, following by the date and time that the reports were generated. These zipped files contain the appropriate "csv" file.

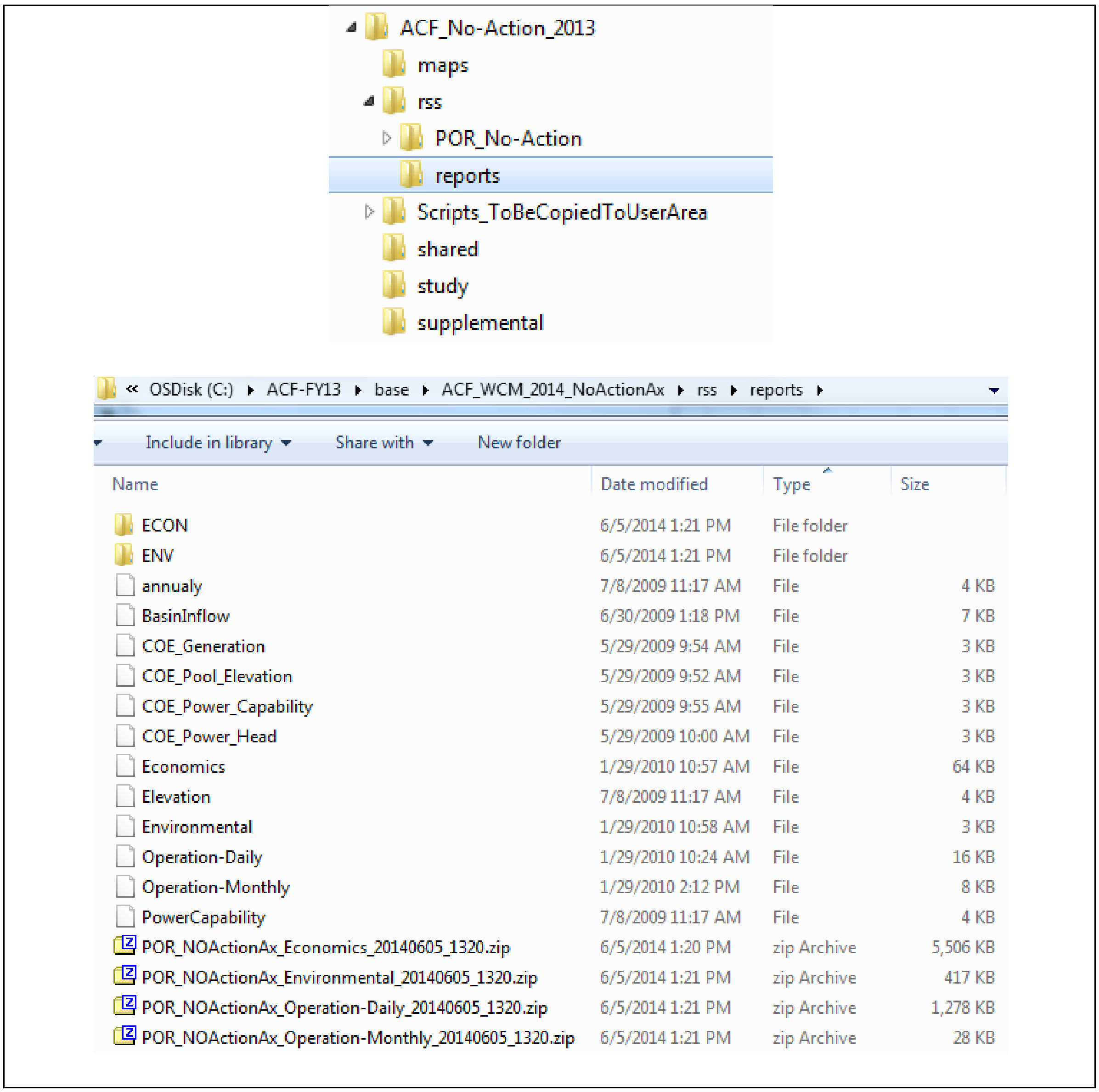

Figure H.33 Folder "reports" with Utility Script Report Templates and Zipped-up Reports Containing Results

The following sections show the script editor, followed by an example portion of the reports for the “Baseline” period-of-record results. Following the report snapshot is the complete contents of the report generation script.

1. *Make-and-Zip_Econ-Reports*

Figure H.34 reflects the Script Editor for the report script named “Make-and-Zip_Econ-Reports”.

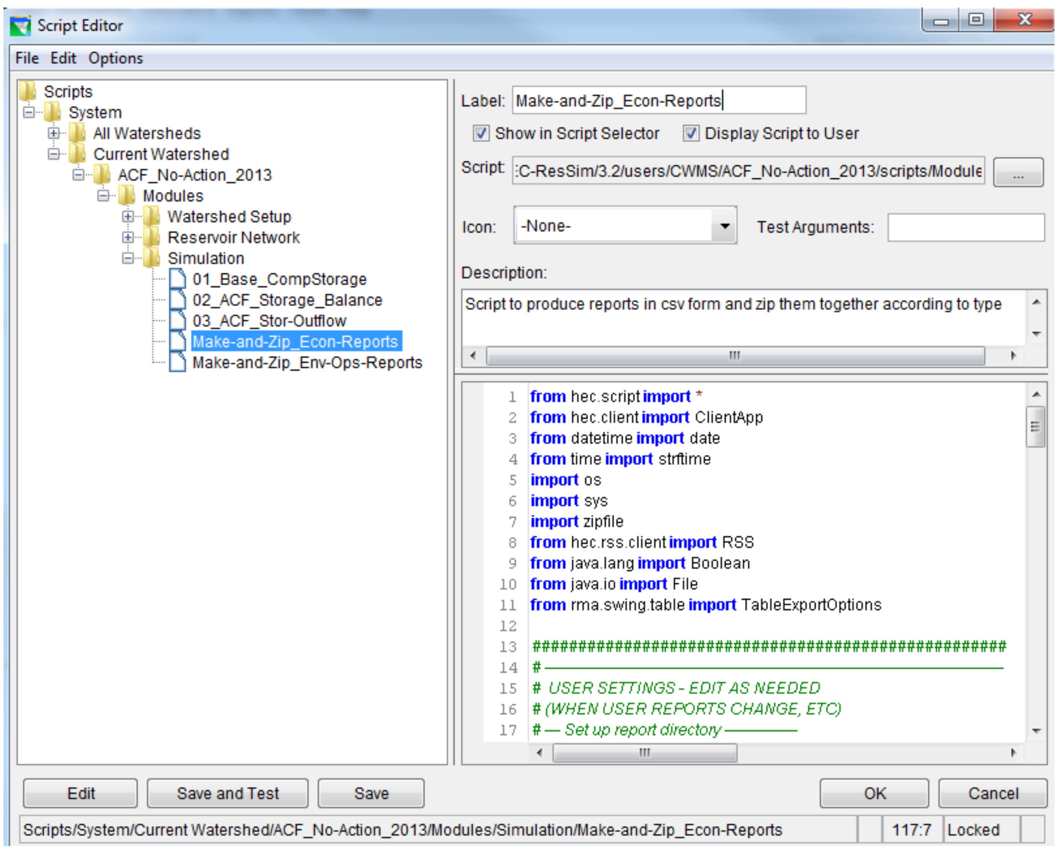

Figure H.34 Script Editor for “Make-and-Zip_Econ-Reports” Report Script

Figure H.35 shows an example snapshot (i.e. a portion) of the report generated by the script named “Make-and-Zip_Econ-Reports” for the “NOActionAx” alternative for the period of record simulation results.

Table H.16 contains the complete contents of the script named “Make-and-Zip_Econ-Reports”.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
NOActionAx	Thu Jun 05	ResSim bu	December 2013														
		BUFORD POOL ELEV (ft)	BUFORD POOL FLOW-OUT (cfs)	BUFORD _OUT FLOW-UNREG (cfs)	BUFORD POWER PLANT POWER (MW)	BUFORD POWER-REQUIRED (undef)	BUFORD POWER PLANT FLOW-QPOWER (cfs)	BUFORD POWER PLANT POWER-CAPABILITY (MW)	BUFORD POWER PLANT POWER-CAPACITY (MW)	BUFORD POWER PLANT ELEV-HEAD POWER (ft)	BUFORD POWER PLANT PLANTFACTOR	BUFORD POWER PLANT ENERGY (MWh)	BUFORD ENERGY-REQUIRED (undef)	MORGAN FALLS POOL ELEV (ft)	MORGAN FALLS POOL FLOW-OUT (cfs)	MORGAN FALLS_OUT FLOW-UNREG (cfs)	MORGAN FALLS POWER PLANT POWER (MW)
4-Jan-39	2400	1070	1021.72	1269.35	12.1		1021.72	116.5	116.5	155.03	0.1	290.32		866	1070	1391.89	3.58
5-Jan-39	2400	1070	1552.47	1312.69	18.31		1552.47	116.5	116.5	154.54	0.16	439.53		866	1630	1446.54	5.35
6-Jan-39	2400	1070	2233.25	1343.85	26.23		2233.25	116.5	116.5	153.97	0.23	629.59		866	2350	1486.24	7.58
7-Jan-39	2400	1070	1722.81	1364.18	20.3		1722.81	116.5	116.5	154.39	0.17	487.22		866	1810	1517.49	5.92
8-Jan-39	2400	1070	1391.49	1373.67	16.43		1391.49	116.5	116.5	154.68	0.14	394.36		866	1460	1543.4	4.82
9-Jan-39	2400	1070	1239.87	1350.67	14.66		1239.87	116.5	116.5	154.82	0.13	351.75		866	1300	1558.7	4.31
10-Jan-39	2400	1070	1164.02	1377.65	13.77		1164.02	116.5	116.5	154.89	0.12	330.41		866	1220	1597.39	4.05
11-Jan-39	2400	1069.99	1836.78	1586.7	14.56		1236.78	116.5	116.5	154.29	0.12	349.5		866	1426.59	1638.53	4.71
12-Jan-39	2400	1069.99	1836.82	1733.93	14.56		1236.82	116.5	116.5	154.29	0.12	349.5		866	2144.85	1893.08	6.95
13-Jan-39	2400	1069.99	1836.81	1827.24	14.56		1236.81	116.5	116.5	154.29	0.13	349.5		866	2174.49	2069.92	7.04
14-Jan-39	2400	1070	1880	1894.91	15.07		1280	116.5	116.5	154.26	0.13	361.62		866	2194.73	2183.48	7.11
15-Jan-39	2400	1070	2084.65	1997.73	17.46		1484.65	116.5	116.5	154.09	0.15	418.92		866	2240.12	2253.33	7.25
16-Jan-39	2400	1070	2231.88	2144.97	19.17		1631.88	116.5	116.5	153.97	0.16	460.05		866	2447.41	2358.81	7.88
17-Jan-39	2400	1070	2156.3	2069.39	18.29		1556.3	116.5	116.5	154.03	0.16	438.95		866	2533.17	2444.57	8.14
18-Jan-39	2400	1070	1922.92	1836	15.57		1322.92	116.5	116.5	154.22	0.13	373.65		866	2423.29	2334.69	7.81
19-Jan-39	2400	1070	1836.75	1699.6	14.56		1236.75	116.5	116.5	154.29	0.13	349.5		866	2148.56	2059.96	6.96
20-Jan-39	2400	1069.99	1836.79	1617.12	14.56		1236.79	116.5	116.5	154.29	0.12	349.5		866	2044.54	1905.7	6.64
21-Jan-39	2400	1070	1485.85	1581.95	10.45		885.85	116.5	116.5	154.59	0.09	250.9		866	2038.3	1816.93	6.62
22-Jan-39	2400	1070	1668.87	1581.95	12.6		1068.87	116.5	116.5	154.44	0.11	302.39		866	1684.82	1779.23	5.53
23-Jan-39	2400	1069.98	1856.44	1482.05	14.79		1256.44	116.5	116.5	154.27	0.13	355		866	1873.68	1785.08	6.11
24-Jan-39	2400	1069.97	1836.96	1433.4	14.56		1236.96	116.5	116.5	154.27	0.12	349.5		866	2049.86	1673.79	6.66
25-Jan-39	2400	1069.95	1837.12	1410.4	14.56		1237.12	116.5	116.5	154.25	0.12	349.5		866	2029.85	1624.6	6.6

Figure H.35 Example Snapshot from Report "POR_NOActionAx0_Economics" Containing "NOActionAx" Period-of-Record Results

Table H.16 Contents of Report Script "Make-and-Zip_Econ-Reports"

```
# name=Make-and-Zip_Econ-Reports
# description=Script to produce reports in csv form and zip them together according to type
# displayinmenu=true
# displaytouser=true
# displayinselector=true
from hec.script import *
from hec.client import ClientApp
from datetime import date
from time import strftime
import os
import sys
import zipfile
from hec.rss.client import RSS
from java.lang import Boolean
from java.io import File
from rma.swing.table import TableExportOptions

####################################################
# ------------------------------------------------------------------------------------------
#  USER SETTINGS - EDIT AS NEEDED
# (WHEN USER REPORTS CHANGE, ETC)
# --- Set up report directory --------------
wkspDirStr = ClientApp.getWorkspaceDir()
# print wkspDirStr
# Change this directory if you desire your reports in a different location
# RepDir = "C:/temp/"
RepDir = wkspDirStr + "/rss/reports/"

# --- Set list of Reports to produce and zip up --------
# Change this list  if you want to generate different user reports
RepList = [ "Economics"]
# [ "BasinInflow", "COE_Generation", "Operations" ]
# ------------------------------------------------------------------------------------------
####################################################

# --- get the active module ------------------------------------------
module = ClientApp.frame().getCurrentModule()
sim = module.getSimulation()
print "YYYYYYYY", sim, sim.getName()
# --- assumes we're in the Simulation mode
simMode = RSS.frame().getCurrentMode()

MessageBox.showPlain( " Generating reports may take awhile for long Simulations that contain many checked Alternatives. \
      \n Press OK to Generate Reports (& Package 'em up).  \n\n Thanks and Have a Great Day!", "For Your Information...")

# To make the files for ALL CHECKED Simulations
# -------------------------------------------------------------------------------
```

```
SimTree = module.getSimulationTree()
checkedRunVec = SimTree.getSelectedRuns() # just checked runs
# checkedRunNameVec = module.getRssRunNames(Boolean.TRUE) # just checked run Names
# RunVec = sim.getSimulationRuns() # all runs, checked or unchecked

# this is a simple error check for now to be sure there is at least one result in the tree
if checkedRunVec.size() == 0:
    MessageBox.showPlain( "No Simulations checked."  , "Error")
    sys.exit() #don't know why this doesn't exit cleanly


# --- Get current time -----------
timeStamp = strftime("%Y%m%d_%H%M")
#print timeStamp
#print date.today()


# -------------------------------------------------------------------------------
# Generate Reports for each of the checked alternatives
#  and zip them up, grouped according to report type
# -------------------------------------------------------------------------------
for Run in checkedRunVec :

  # set the run as the active run
  module.setActiveRun(Run)

  for Rep in RepList :

      # open the report
      userReport = simMode.displayUserReportByName(Rep, 0)
      #print "---------------------", userReport, sim, Run
      # open the report
      if userReport != None:
          # where to save it
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          Repfile = File(csvFilename)
          #  what options to use
          opts = TableExportOptions()
          # comma separated
          opts.delimiter = ','
          # write it out
          userReport.getReportPanel().exportReportAction(Repfile, opts)
          # close the report
          userReport.setVisible(0)

          # ------------------------------------------------------------------------------------------------------------------------
          # For some reason, the zipfile append option isn't working, therefore, all this code is commented out
          #  Instead, all the csv files are being written into the zipfile at the same time at the end of the script.
          # zip up the file
          #zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
          #if os.path.exists(zipName) :
```

```
          #   z = zipfile.ZipFile(zipName, "a")
          #else :
          #   z = zipfile.ZipFile(zipName, "w")
          #z.write(csvFilename)
          #z.close()
          # clean up csv files
          #os.remove(csvFilename)
          # --------------------------------------------------------------------------------------------------------------------------
-----------



# write all the csv files into the appropriate zipfiles
# -----------------------------------------------------------------
# make the currrent working directory the reports directory
cur_cwd=os.getcwd()
print "cwd before", os.getcwd()
os.chdir(RepDir)
print "cwd after", os.getcwd()
for Rep in RepList :
    # zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     zipName = sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     z = zipfile.ZipFile(zipName, "w", zipfile.ZIP_DEFLATED)

     for Run in checkedRunVec :
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          shortname = sim.getName()+"_"+Run.getName()+"_"+Rep+".csv"
          bytename=shortname.encode('ascii')
               #z.write(csvFilename, os.path.basename(csvFilename))
          z.write(bytename)
          #os.remove(csvFilename)

     z.close()
# return to original working directory
os.chdir(cur_cwd)
print "cwd returned", os.getcwd()

MessageBox.showPlain( "Reports have successfully been zipped and written to this location: \n     %s" % RepDir, "Reports Generated and
Collected into Zip File(s)")
```

2. Make-and-Zip_Env-Ops-Reports

Figure H.36 reflects the Script Editor for the report script named "Make-and-Zip_Env-Ops-Reports".

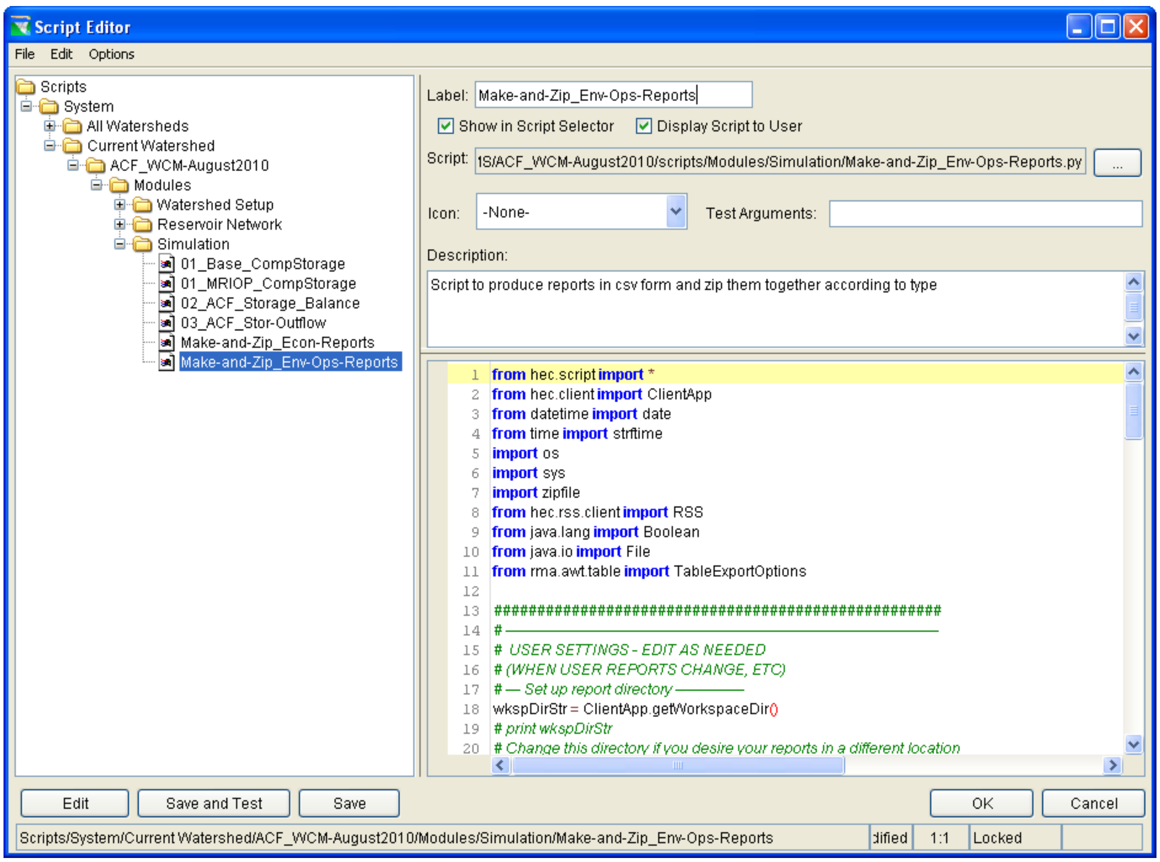

Figure H.36 Script Editor for "Make-and-Zip_Env-Ops-Reports" Report Script

Figure H.37, Figure H.38, and Figure H.39 show example snapshots (i.e. a portion) of each of the environmental and operations reports (daily and monthly) generated by the script named "Make-and-Zip_Env-Ops-Reports" for the "NOActionAx" alternative for the period of record simulation results.

Table H.17 contains the complete contents of the script named "Make-and-Zip_Env-Ops-Reports".

A	B	C	D	E	F
NOActionAx	Thu Jun 05	ResSim build=3.2.1.1	December 2013		
		CHATTAHOOCHEE FLOW (cfs)	CHATTAHOOCHEE FLOW-UNREG (cfs)	CHATTAHOOCHEE STAGE (ft)	CHATTAHOOCHEE STAGE-UNREG (ft)
--					
4-Jan-39	2400	9490	10032.5	41.69	41.97
5-Jan-39	2400	9490	10320.14	41.69	42.12
6-Jan-39	2400	10200	10547.89	42.06	42.25
7-Jan-39	2400	11700	10727.96	42.82	42.35
8-Jan-39	2400	12000	10934.26	42.95	42.46
9-Jan-39	2400	11500	11247.68	42.73	42.61
10-Jan-39	2400	11300	11712.34	42.64	42.82
11-Jan-39	2400	15520.01	11936.43	44.6	42.93
12-Jan-39	2400	14508.71	12322.33	44.14	43.11
13-Jan-39	2400	13568.43	13127.75	43.71	43.51
14-Jan-39	2400	12700.81	13773.81	43.3	43.81
15-Jan-39	2400	13203.96	14385.39	43.55	44.08
16-Jan-39	2400	14008.17	14866.43	43.91	44.3
17-Jan-39	2400	14314.56	15157.72	44.05	44.44
18-Jan-39	2400	14502.6	15191.73	44.14	44.45
19-Jan-39	2400	14648.3	14783.61	44.2	44.27
20-Jan-39	2400	14665.08	13781.11	44.21	43.81
21-Jan-39	2400	14462.71	12870.66	44.12	43.39
22-Jan-39	2400	13945.35	11861.31	43.88	42.89
23-Jan-39	2400	13048.55	11206.59	43.47	42.59
24-Jan-39	2400	12221.19	10769.4	43.06	42.37
25-Jan-39	2400	11454.9	10758.41	42.71	42.37

POR NOActionAx NOActionAx0_Envi

Figure H.37 Example Snapshot from Report "POR_NOActionAx0_Environmental" Containing "NOActionAx" Period-of-Record Results

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NOActionAx	Thu Jun 05	ResSim bu	December 2013											
		BUFORD POOL ELEV (ft)	WEST POINT POOL ELEV (ft)	WALTER F GEORGE POOL ELEV (ft)	JIM WOODR UFF POOL ELEV (ft)	BLOUNT STOWN STAGE (ft)	CHATTAH OOCHEE FLOW (cfs)	BUFORD POWER PLANT ENERGY (MWh)	WEST POINT POWER PLANT ENERGY (MWh)	WALTER F GEORGE POWER PLANT ENERGY (MWh)	JIM WOODR UFF POWER PLANT ENERGY (MWh)	BUFORD POWER PLANT POWER-CAPABILI TY (MW)	WEST POINT POWER PLANT POWER-CAPABILI TY (MW)	WALTER F GEORGE POWER PLANT POWER-CAPABILI TY (MW)
4-Jan-39	2400	1070	628	188	77.8	4.16	9490	290.32	278.93	632.58	589.88	116.5	85.5	167.6
5-Jan-39	2400	1070	628	188	77.8	4.11	9490	439.53	339.47	768.44	589.88	116.5	85.5	167.6
6-Jan-39	2400	1070	628	188	77.8	4.29	10200	629.59	517.98	992.9	632.68	116.5	85.5	167.6
7-Jan-39	2400	1070	628	188	77.8	4.85	11700	487.22	507.91	1058.53	704.86	116.5	85.5	167.6
8-Jan-39	2400	1070	628	188	77.8	5.36	12000	394.36	467.43	992.9	719.1	116.5	85.5	167.6
9-Jan-39	2400	1070	628	188	77.8	5.41	11500	351.75	397.01	909.73	695.25	116.5	85.5	167.6
10-Jan-39	2400	1070	628	188	77.8	5.26	11300	330.41	339.47	784.06	685.55	116.5	85.5	167.6
11-Jan-39	2400	1069.99	628	188	77.57	6.1	15520.01	349.5	424.53	864.42	861.49	116.5	85.5	167.6
12-Jan-39	2400	1069.99	628	188	77.43	6.95	14508.71	349.5	501.78	1030.96	814.02	116.5	85.5	167.6
13-Jan-39	2400	1069.99	628	188	77.39	6.69	13568.43	349.5	569.74	1141.13	771.28	116.5	85.5	167.6
14-Jan-39	2400	1070	628	188	77.43	6.29	12700.81	361.62	649.12	1252.74	733.51	116.5	85.5	167.6
15-Jan-39	2400	1070	628	188	77.48	6.12	13203.96	418.92	676.39	1370.11	756.73	116.5	85.5	167.6
16-Jan-39	2400	1070	628	188	77.53	6.37	14008.17	460.05	696.15	1439.83	793.06	116.5	85.5	167.6
17-Jan-39	2400	1070	628	188	77.57	6.65	14314.56	438.95	660.58	1461.96	807.41	116.5	85.5	167.6
18-Jan-39	2400	1070	628	188	77.6	6.83	14502.6	373.65	565.5	1388.67	816.53	116.5	85.5	167.6
19-Jan-39	2400	1070	628	188	77.61	6.9	14648.3	349.5	482.44	1229.04	823.21	116.5	85.5	167.6
20-Jan-39	2400	1069.99	628	188	77.56	6.95	14665.08	349.5	431.66	1108.21	823.2	116.5	85.5	167.6
21-Jan-39	2400	1070	628	188	77.48	6.93	14462.71	250.9	384.4	1000.57	812.69	116.5	85.5	167.6
22-Jan-39	2400	1070	628	188	77.37	6.78	13945.35	302.39	361.43	915.57	787.89	116.5	85.5	167.6
23-Jan-39	2400	1069.98	628	188	77.28	6.45	13048.55	355	347.91	857.33	746.07	116.5	85.5	167.6
24-Jan-39	2400	1069.97	627.99	188	77.21	6.02	12221.19	349.5	342.07	839.97	707.68	116.5	85.5	167.6
25-Jan-39	2400	1069.95	627.97	188	77.18	5.57	11454.9	349.5	342.07	883.61	670.91	116.5	85.5	167.6

POR NOActionAx NOActionAx0 Oper

Figure H.38 Example Snapshot from Report "POR_NOActionAx0_Operation-Daily" Containing "NOActionAx" Period-of-Record Results

A	B	C	D	E	F	G	H	I	J	K	L	M	N
NOActionAx	Thu Jun 05	ResSim bu	December 2013										
		BUFORD POWER PLANT ENERGY (MWh)	WEST POINT POWER PLANT ENERGY (MWh)	WALTER F GEORGE POWER PLANT ENERGY (MWh)	JIM WOODRUFF POWER PLANT ENERGY (MWh)	BUFORD POWER PLANT POWER-CAPABILITY (MW)	WEST POINT POWER PLANT POWER-CAPABILITY (MW)	WALTER F GEORGE POWER PLANT POWER-CAPABILITY (MW)	JIM WOODRUFF POWER PLANT POWER-CAPABILITY (MW)	BUFORD POWER PLANT POWER-CAPACITY (MW)	WEST POINT POWER PLANT POWER-CAPACITY (MW)	WALTER F GEORGE POWER PLANT POWER-CAPACITY (MW)	JIM WOODRUFF POWER PLANT POWER-CAPACITY (MW)
28-Feb-39	2400	34367.97	34608.2	72712.88	22891.55	116.46	81.1	166.69	35.09	116.46	85.44	167.53	35.28
31-Mar-39	2400	24895.64	30261.36	76732.5	20313.33	116.49	83.78	161.69	27.3	116.49	85.17	164.8	27.48
30-Apr-39	2400	11212.1	15971.62	52677.97	24734.52	116.5	85.5	167.01	34.35	116.5	85.5	167.59	34.72
31-May-39	2400	15456.26	14099.92	32324.96	29236.53	116.5	85.5	167.6	40.11	116.5	85.5	167.6	40.67
30-Jun-39	2400	8091.23	14501.98	38414.72	27708.05	116.5	85.5	167.6	39.81	116.5	85.5	167.6	40.34
31-Jul-39	2400	8537.11	8597.72	29672.62	27315.78	116.5	85.5	167.6	41.96	116.5	85.5	167.6	42.24
31-Aug-39	2400	8753.91	17222.86	58383.35	24815.17	116.5	85.5	167.6	37.08	116.5	85.5	167.6	37.2
30-Sep-39	2400	8554.22	7777.25	27750.98	25120.08	116.5	85.5	167.6	41.54	116.5	85.5	167.6	41.76
31-Oct-39	2400	8850.25	7525.5	23709.28	23700.71	116.5	85.5	167.6	42.77	116.5	85.5	167.6	42.87
30-Nov-39	2400	7127.22	9536.06	25901.22	19396.09	115.89	85.5	167.6	43.2	115.89	85.5	167.6	43.2
31-Dec-39	2400	5834.55	9173.39	28835.92	21088.22	114.79	85.5	167.6	43.18	114.79	85.5	167.6	43.18
31-Jan-40	2400	5682.22	13423.32	42455.68	26401.37	114.36	85.15	167.6	40.11	114.36	85.5	167.6	40.37
29-Feb-40	2400	5037.27	13909.4	62713.5	21287.99	114.7	85.5	166.52	31	114.7	85.5	167.58	31.2
31-Mar-40	2400	4969.27	17552.47	51940.62	25710.27	115.92	85.5	167.6	34.56	115.92	85.5	167.6	34.9
30-Apr-40	2400	5276.87	11611.72	40816.34	26700.07	116.47	85.5	167.6	37.16	116.47	85.5	167.6	37.62
31-May-40	2400	6030.85	7646.52	20700.68	23537.46	116.5	85.5	167.6	42.19	116.5	85.5	167.6	42.45
30-Jun-40	2400	5592.05	5936.83	18106.29	18080.81	116.28	85.5	167.6	43.2	116.28	85.5	167.6	43.2
31-Jul-40	2400	5748.67	21756.67	65179.08	23540.33	115.69	85.5	167.6	34.91	115.69	85.5	167.6	35.08
31-Aug-40	2400	5580.01	10083.54	26958.26	23112.17	115.79	85.5	167.6	43.01	115.79	85.5	167.6	43.06
30-Sep-40	2400	6860.63	7183.42	18306.73	16378.96	116.48	85.5	167.6	43.2	116.48	85.5	167.6	43.2
31-Oct-40	2400	6421.11	7867.54	20408.41	15562.65	115.56	85.5	167.6	43.2	115.56	85.5	167.6	43.2
30-Nov-40	2400	5833.41	7183.39	25024.14	19037.16	114.44	85.5	167.6	43.19	114.44	85.5	167.6	43.19
31-Dec-40	2400	5699.82	13119.33	34146.42	23979	113.85	85.5	167.6	42.94	113.85	85.5	167.6	42.97

POR_NOActionAx_NOActionAx0_Oper

Figure H.39 Example Snapshot from Report "POR_ NOActionAx0_Operation-Monthly" Containing Monthly Summaries of "NOActionAx" Period-of-Record Results

Table H.17 Contents of Report Script "Make-and-Zip_Env-Ops-Reports"

```
# name=Make-and-Zip_Env-Ops-Reports
# description=Script to produce reports in csv form and zip them together according to type
# displayinmenu=true
# displaytouser=true
# displayinselector=true
from hec.script import *
from hec.client import ClientApp
from datetime import date
from time import strftime
import os
import sys
import zipfile
from hec.rss.client import RSS
from java.lang import Boolean
from java.io import File
from rma.swing.table import TableExportOptions

####################################################
# ------------------------------------------------------------------------------------------
#  USER SETTINGS - EDIT AS NEEDED
# (WHEN USER REPORTS CHANGE, ETC)
# --- Set up report directory --------------
wkspDirStr = ClientApp.getWorkspaceDir()
# print wkspDirStr
# Change this directory if you desire your reports in a different location
# RepDir = "C:/temp/"
RepDir = wkspDirStr + "/rss/reports/"

# --- Set list of Reports to produce and zip up --------
# Change this list  if you want to generate different user reports
RepList = ["Environmental", "Operation-Daily", "Operation-Monthly"]
# [ "BasinInflow", "COE_Generation", "Operations" ]
# ------------------------------------------------------------------------------------------
####################################################

# --- get the active module ------------------------------------------
module = ClientApp.frame().getCurrentModule()
sim = module.getSimulation()
print "YYYYYYYY", sim, sim.getName()
# --- assumes we're in the Simulation mode
simMode = RSS.frame().getCurrentMode()

MessageBox.showPlain( " Generating reports may take awhile for long Simulations that contain many checked Alternatives. \
      \n Press OK to Generate Reports (& Package 'em up).  \n\n Thanks and Have a Great Day!", "For Your Information...")

# To make the files for ALL CHECKED Simulations
# ------------------------------------------------------------------------------
```

```
SimTree = module.getSimulationTree()
checkedRunVec = SimTree.getSelectedRuns() # just checked runs
# checkedRunNameVec = module.getRssRunNames(Boolean.TRUE) # just checked run Names
# RunVec = sim.getSimulationRuns() # all runs, checked or unchecked

# this is a simple error check for now to be sure there is at least one result in the tree
if checkedRunVec.size() == 0:
    MessageBox.showPlain( "No Simulations checked."  , "Error")
    sys.exit() #don't know why this doesn't exit cleanly


# --- Get current time -----------
timeStamp = strftime("%Y%m%d_%H%M")
#print timeStamp
#print date.today()


# --------------------------------------------------------------------------------
# Generate Reports for each of the checked alternatives
#  and zip them up, grouped according to report type
# --------------------------------------------------------------------------------
for Run in checkedRunVec :

  # set the run as the active run
  module.setActiveRun(Run)

  for Rep in RepList :

      # open the report
      userReport = simMode.displayUserReportByName(Rep, 0)
      #print "---------------------", userReport, sim, Run
      # open the report
      if userReport != None:
          # where to save it
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          Repfile = File(csvFilename)
          #  what options to use
          opts = TableExportOptions()
          # comma separated
          opts.delimiter = ','
          # write it out
          userReport.getReportPanel().exportReportAction(Repfile, opts)
          # close the report
          userReport.setVisible(0)

          # ------------------------------------------------------------------------------------------------------------------------------
          # For some reason, the zipfile append option isn't working, therefore, all this code is commented out
          #  Instead, all the csv files are being written into the zipfile at the same time at the end of the script.
          # zip up the file
          #zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
          #if os.path.exists(zipName) :
```

```
          #   z = zipfile.ZipFile(zipName, "a")
          #else :
          #   z = zipfile.ZipFile(zipName, "w")
          #z.write(csvFilename)
          #z.close()
          # clean up csv files
          #os.remove(csvFilename)
          # -----------------------------------------------------------------------------------------------------------------------------



# write all the csv files into the appropriate zipfiles
# ------------------------------------------------------------------
# make the currrent working directory the reports directory
cur_cwd=os.getcwd()
print "cwd before", os.getcwd()
os.chdir(RepDir)
print "cwd after", os.getcwd()
for Rep in RepList :
    # zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     zipName = sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     z = zipfile.ZipFile(zipName, "w", zipfile.ZIP_DEFLATED)

     for Run in checkedRunVec :
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          shortname = sim.getName()+"_"+Run.getName()+"_"+Rep+".csv"
          bytename=shortname.encode('ascii')
               #z.write(csvFilename, os.path.basename(csvFilename))
          z.write(bytename)
          #os.remove(csvFilename)

     z.close()
# return to original working directory
os.chdir(cur_cwd)
print "cwd returned", os.getcwd()

MessageBox.showPlain( "Reports have successfully been zipped and written to this location: \n     %s" % RepDir, "Reports Generated and 
Collected into Zip File(s)")
```

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix I – Flood Modeling
West Point to Columbus

August 2010

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Appendix I – Flood Modeling

List of Sections

List of Tables:

List of Figures:

Flood Modeling – West Point to Columbus

(Evaluation of Flood Impact of West Point Flood Operation at Columbus)

I. Introduction

The Mobile District is evaluating two flood operation alternatives at West Point Dam. Figure I.01 shows the conservation zone guide curves for three scenarios. In the Early Refill condition, West Point Lake starts refill on February 1, 15 days earlier than the refill schedule for the Baseline condition. In summer months, the pool elevation is the same. However, the pool is much lower in the fall months for the Early Refill condition. In December, compared to the Baseline condition, the pool is higher for most of the time. For the Fall Stepped-down condition, the guide curve in January through August is the same as the guide curve in the Baseline condition. However, a stepped-down pattern is proposed for September through December.

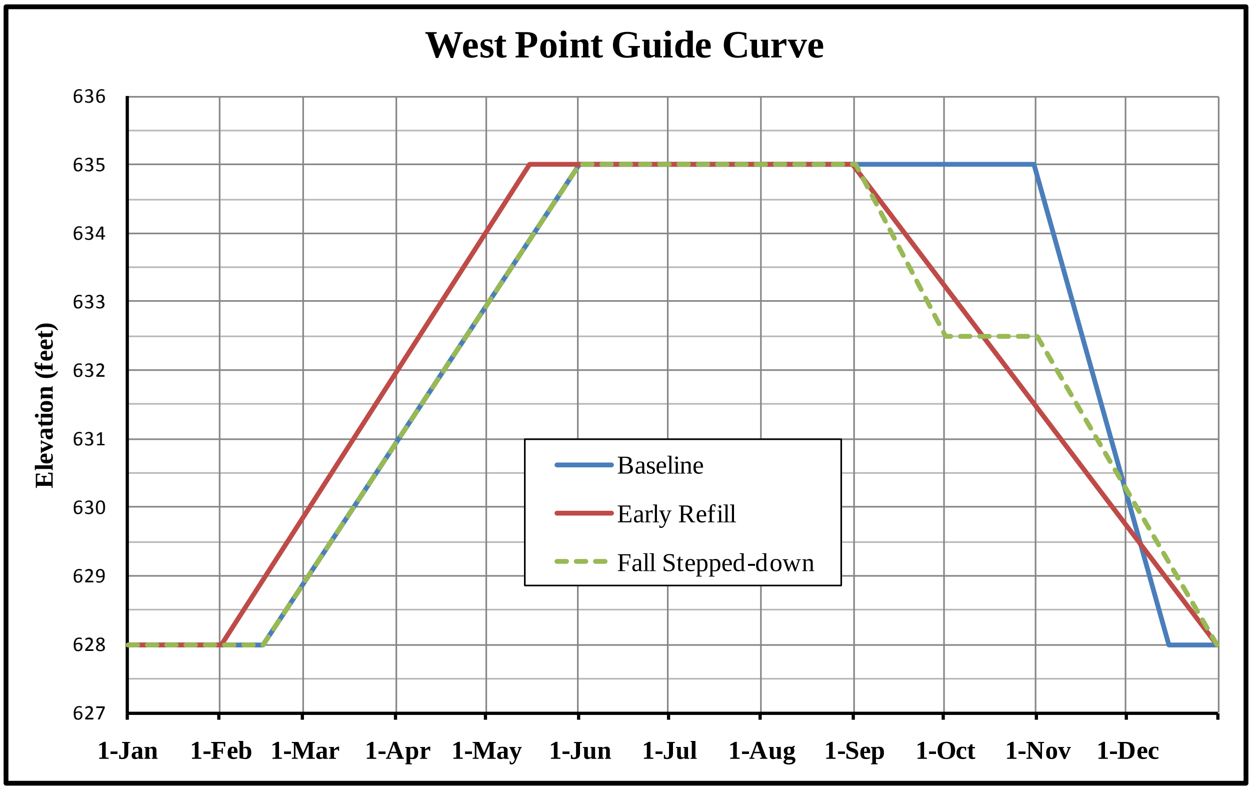

Figure I.01 West Point Guide Curve – Three Operation Sets (Baseline, Early Refill, and Fall Stepped-Down)

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. For the Chattahoochee River between West Point and Columbus, the flood damage site is at Columbus. A flood operation alternative is acceptable only if it does not significantly increase the flood frequency curves at Columbus. This appendix describes the approach used to evaluate the flood impacts of West Point Dam operations on the flood conditions at Columbus. The appendix also presents the results.

II. Study Approach

The flow in the Chattahoochee River at Columbus is regulated. The magnitude of flood discharge at Columbus is primarily influenced by the magnitude of storms. At the same time, due to flow regulation, it is also affected by flood operations at West Point Dam and the upstream dams, which typically vary month to month as indicated in Figure I.01. Therefore, the combined regulated flood frequency relationship at Columbus is 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 Columbus 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 Columbus using the total probability theorem (U.S. Army Corps of Engineers, 1993). This approach is illustrated in detail in the following Section.

III. Procedures to Develop Combined Regulated Flood Frequency Curves

A. Step 1 – Develop Hypothetical Hydrographs

This step was completed by the Mobile District (U.S. Army Corps of Engineers, 2009). The unimpaired flow records at Columbus were used to develop the peak, 1-day, 3-day, and 45-day unregulated flow frequency curves at Columbus. Using the unimpaired hydrographs for the March 1990 and May 2003 events that had distinctly different storm patterns in the basin above Columbus, a calibrated HEC-HMS model that extends from Buford to Columbus was used to iteratively determine the hourly unimpaired 5-, 2-, 1-, 0.5-, and 0.2-percent-annual chance storm hydrographs at each inflow node in the HEC-HMS model (Figure I.02). Figure I.03 and Figure I.04 show the two sets of unimpaired hypothetical storm hydrographs at West Point Lake.

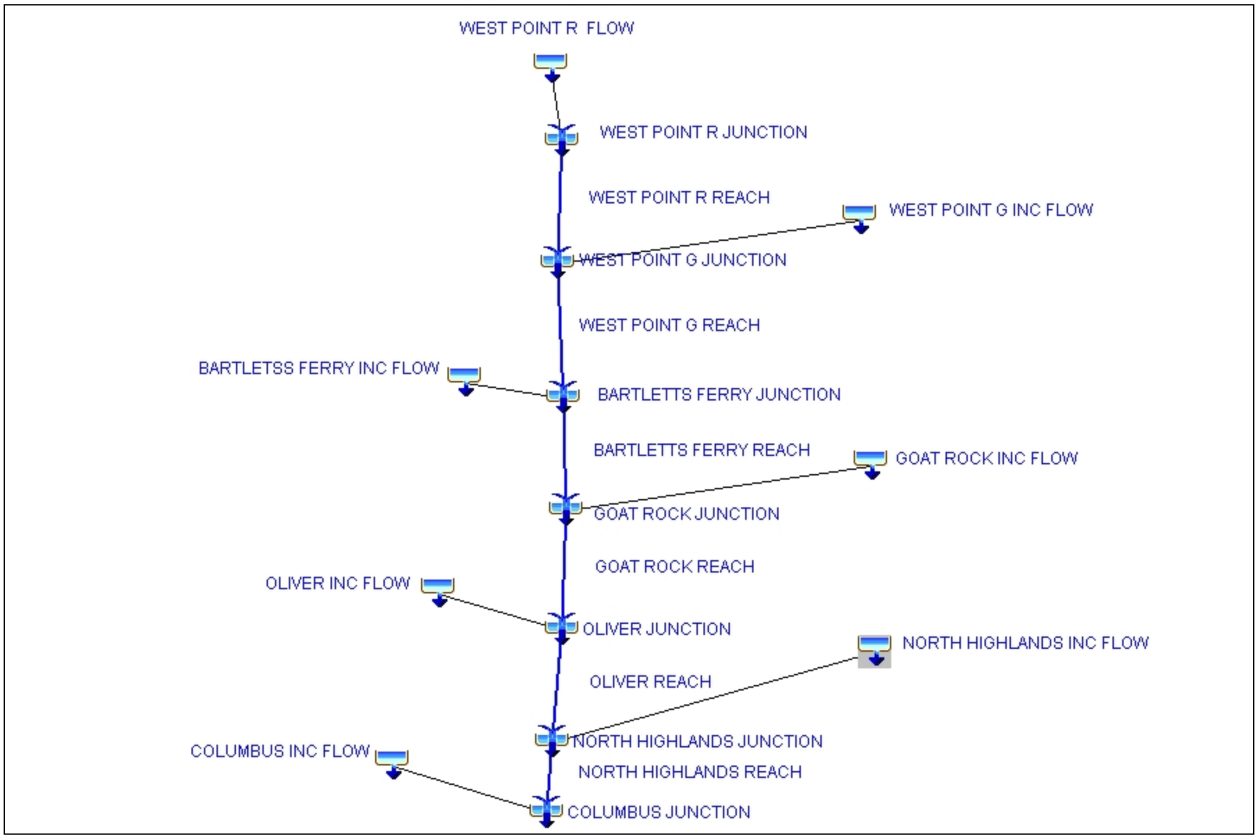

Figure I.02 Schematic of HEC-HMS Model

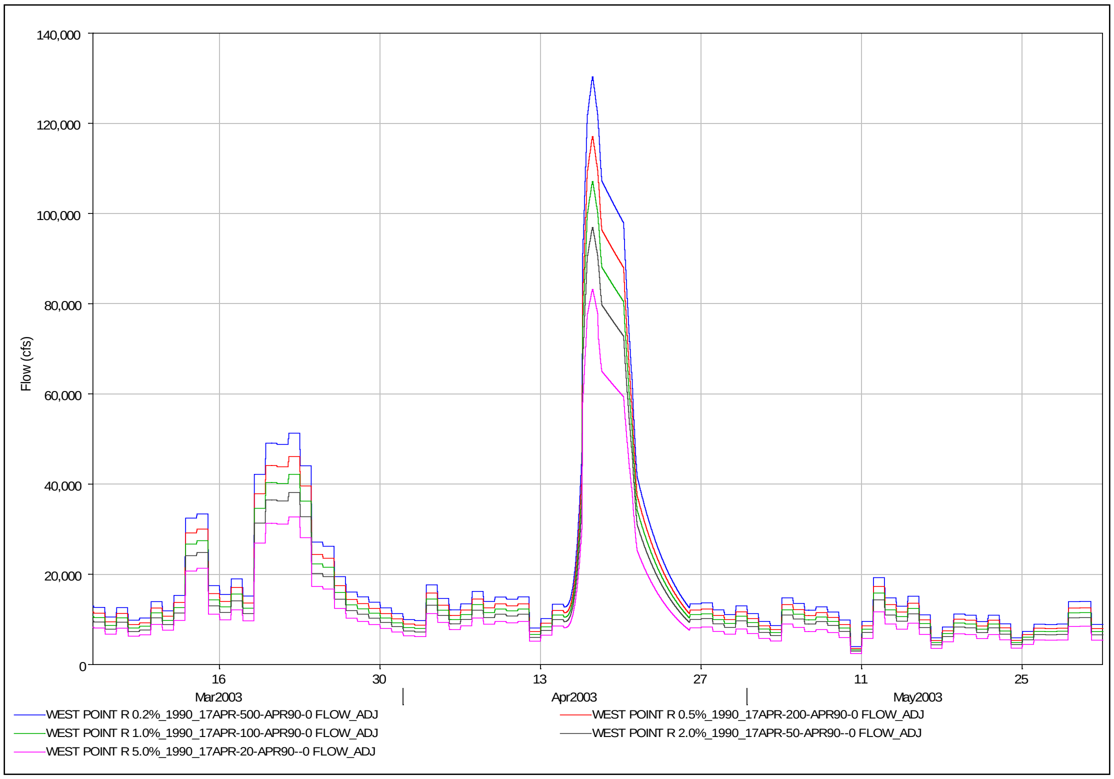

Figure I.03 Hypothetical Hydrographs at West Point Based on Shapes of March 1990 Hydrographs

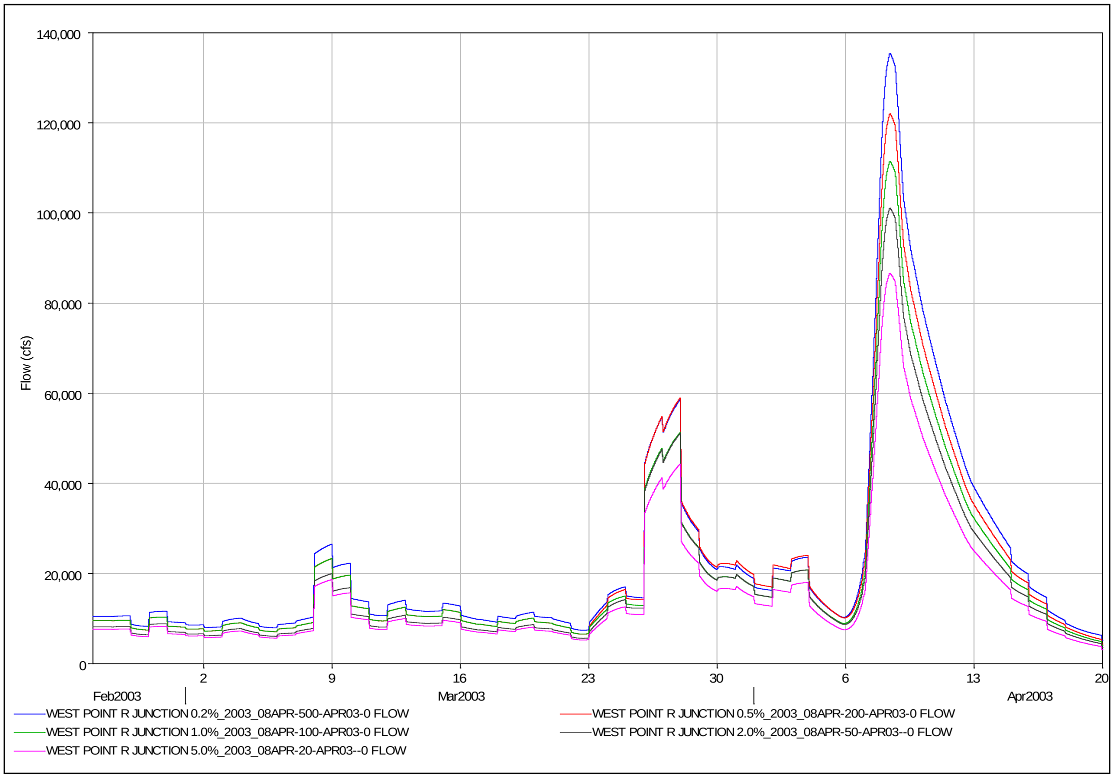

Figure I.04 Hypothetical Hydrographs at West Point Based on Shapes of May 2003 Hydrographs

B. Step 2 – Develop and Run a Reservoir Model

An hourly HEC-ResSim flood model for the Chattahoochee River from West Point Lake to Columbus was developed as part of the ACF Water Control Manual Update Study. Using the two sets of hypothetical hydrographs and the three sets of the West Point guide curves (Figure I.01), a series of simulation alternatives were created in HEC-ResSim. Table I.1 summarizes all the simulations.

Table I.1 Summary of HEC-ResSim Simulation Alternatives

Name of Simulations (by month)	Hydrograph Type		West Point Operation Set		
	March 1990	May 2003	Baseline	Early Refill	Fall Stepped-down[1]
HypEvents_Jan1990	x		x	x	
HypEvents_Feb1990	x		x	x	
HypEvents_Mar1990	x		x	x	
HypEvents_Apr1990	x		x	x	
HypEvents_May1990	x		x	x	
HypEvents_Jun1990	x		x	x	
HypEvents_Jul1990	x		x	x	
HypEvents_Aug1990	x		x	x	
HypEvents_Sep1990	x		x	x	x
HypEvents_Oct1990	x		x	x	x
HypEvents_Nov1990	x		x	x	x
HypEvents_Dec1990	x		x	x	x
HypEvents_Jan2003		x	x	x	
HypEvents_Feb2003		x	x	x	
HypEvents_Mar2003		x	x	x	
HypEvents_Apr2003		x	x	x	
HypEvents_May2003		x	x	x	
HypEvents_Jun2003		x	x	x	
HypEvents_Jul2003		x	x	x	
HypEvents_Aug2003		x	x	x	
HypEvents_Sep2003		x	x	x	x
HypEvents_Oct2003		x	x	x	x
HypEvents_Nov2003		x	x	x	x
HypEvents_Dec2003		x	x	x	x

[1]Note: The "Fall Stepped-down" simulations were run for September through December only because the guide curve in January through August is the same as that for the "Baseline" condition.

C. Step 3 – Construct Monthly Regulated Flood Frequency Curves

The flow hydrographs computed by HEC-ResSim for each month at Columbus represent the monthly regulated hypothetical hydrographs. Figure I.05 and Figure I.06 show the November regulated 1-percent-annual-chance hypothetical storm hydrographs at Columbus.

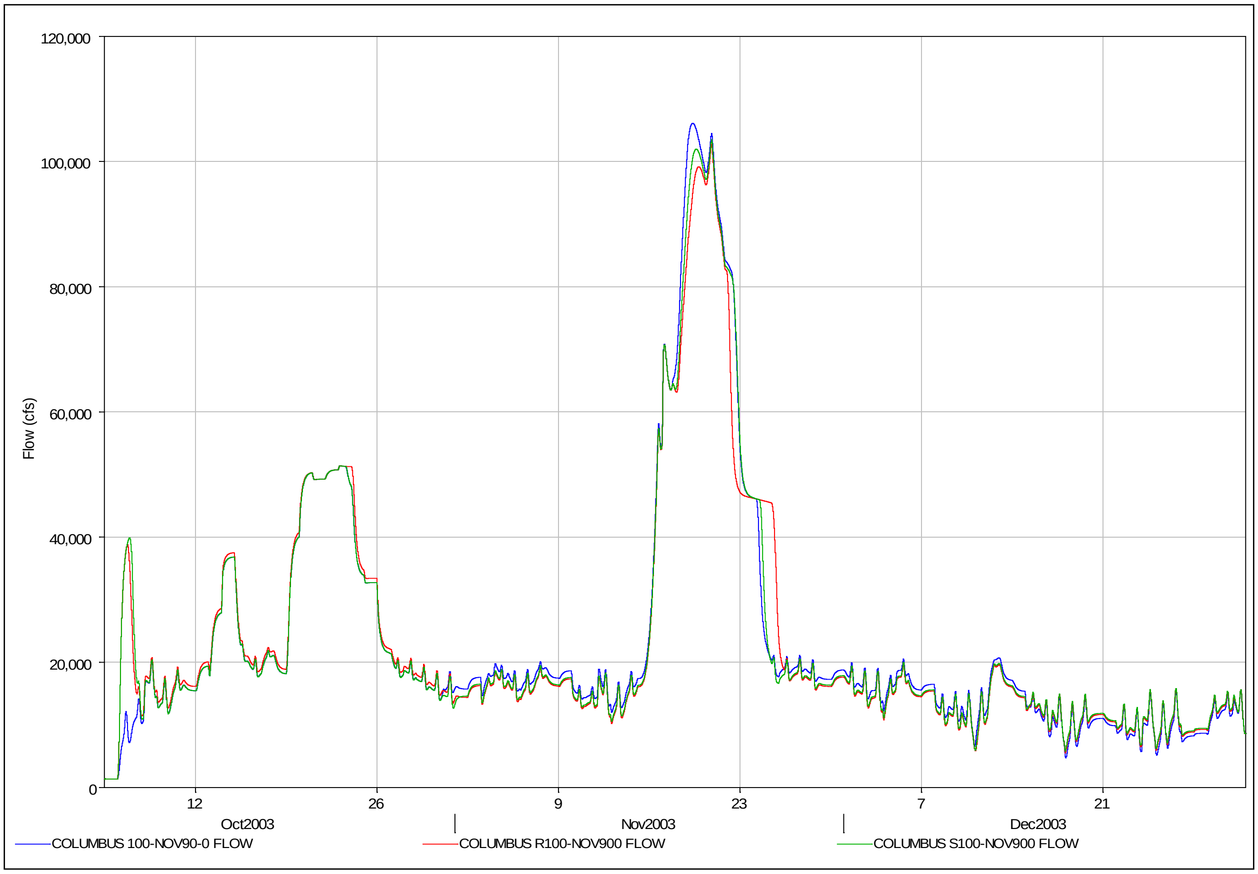

Figure I.05 Regulated November 1% Storm Hydrographs for the Baseline, Early Refill, and Fall Stepped-down Conditions (based on March 1990 hydrograph shapes).

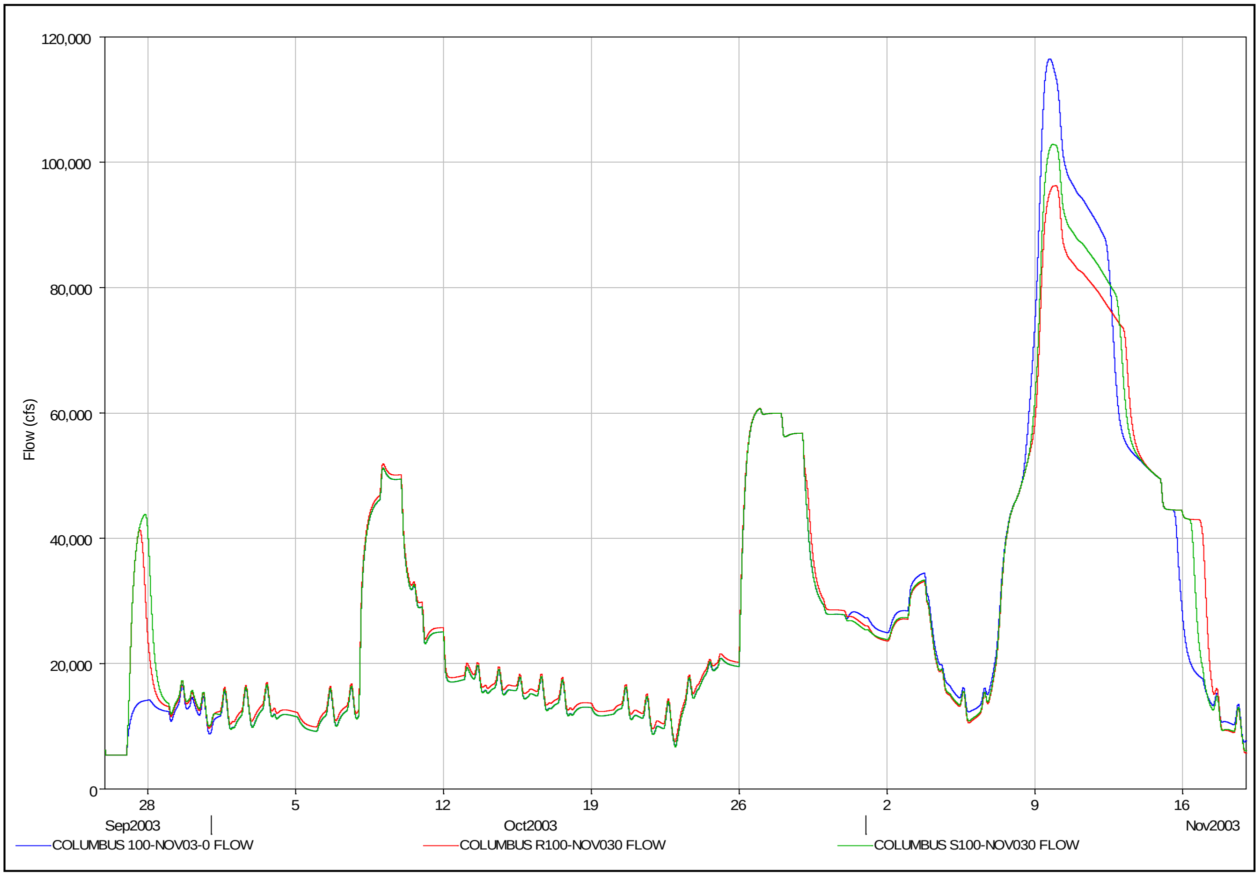

Figure I.06 Regulated November 1% Storm Hydrographs for the Baseline, Early Refill, and Fall Stepped-down Conditions (based on May 2003 hydrograph shapes).

For each month, the peak discharges of the 5-, 2-, 1-, 0.5-, and 0.2-percent regulated hydrographs at Columbus define the regulated flood frequency curves for the Baseline, Early Refill, and Fall Stepped-down conditions, respectively. Table I.2 includes the monthly regulated flood frequency flows at Columbus.

Table I.2 Monthly Regulated Flood Frequency Flow at Columbus

January Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	127846			117646		
0.5	112526			92982		
1	99197			83945		
2	79771			79788		
5	62834			74136		

Note: The frequency flows are same for the "Baseline", "Early Refill", and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

February Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	127959	130390		117730	120774	
0.5	112694	113577		93044	95874	
1	99496	101216		83953	83953	
2	80392	85719		79796	79796	
5	62842	62842		74144	74144	

Note: The frequency flows are same for the "Baseline" and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

March Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	133024	136184		126627	133070	
0.5	114318	116213		102069	109303	
1	102185	103134		85431	91151	
2	89601	92010		79799	79799	
5	62845	63779		74147	74147	

Note: The frequency flows are same for the "Baseline" and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

April Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	139429	142290		139656	147429	
0.5	119856	123872		116721	123894	
1	104396	108619		98310	106082	
2	93236	94349		82652	89270	
5	68833	73091		74123	74123	

Note: The frequency flows are same for the "Baseline" and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

… Continued …

Table I.2 Monthly Regulated Flood Frequency Flow at Columbus - *Continued*

May Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	146328	151457		154611	163848	
0.5	126825	131484		129805	138376	
1	112230	115542		113041	120126	
2	97633	102231		95873	104182	
5	74977	78027		75323	82432	

Note: The frequency flows are same for the "Baseline" and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

June Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	151487			167751		
0.5	131520			144001		
1	115576			124363		
2	102259			108228		
5	78057			85843		

Note: The frequency flows are same for the "Baseline", "Early Refill", and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

July Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	151588			167866		
0.5	131634			144141		
1	115687			124485		
2	102353			108341		
5	78157			85943		

Note: The frequency flows are same for the "Baseline", "Early Refill", and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

August Regulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	151349			167592		
0.5	131362			143803		
1	115423			124193		
2	102128			108070		
5	77919			85706		

Note: The frequency flows are same for the "Baseline", "Early Refill", and "Fall Stepped-down" simulations as the West Point guide curves remain the same.

… Continued …

Table I.2 Monthly Regulated Flood Frequency Flow at Columbus - *Continued*

September Unregulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	151374	146628	144740	167616	164611	163792
0.5	131386	126932	125899	143827	139224	138275
1	115447	112379	111035	124217	120676	119984
2	102153	97828	96270	108095	104831	103968
5	77944	75000	74430	85730	82878	82206

October Unregulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	151371	140248	140685	167615	150348	147720
0.5	131385	120921	121565	143828	126482	124140
1	115445	105493	106181	124216	109174	106381
2	102150	93441	93623	108093	92050	89512
5	77941	70236	70984	85728	74075	74075

November Unregulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	140745	134837	137450	159164	137518	144477
0.5	121550	114845	117573	133326	114583	121246
1	106115	102774	103491	116484	96294	102869
2	93755	91233	92558	99327	80955	86637
5	70909	62891	65636	78425	74138	74138

December Unregulated Frequency Flow in cfs at Columbus.

Exceedance Probability (%)	March 1990 Hydrograph Shape			May2003 Hydrograph Shape		
	Baseline	Early Refill	Fall Stepped-down	Baseline	Early Refill	Fall Stepped-down
0.2	127852	129683	130437	125766	126780	129573
0.5	112532	113321	113546	101122	102185	105147
1	99202	100788	101187	84765	85489	87691
2	79777	84211	85711	79792	79792	79792
5	62838	62883	62905	74141	74141	74141

D. Step 4 – Determine Probabilities of Hypothetical Hydrographs Occurring in Each Month

A flood event in the Chattahoochee River 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 distributions. In this study, to evaluate the seasonal likelihood of a large flood, the unimpaired daily flow records at Columbus 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 West Point gage (Figure I.07).

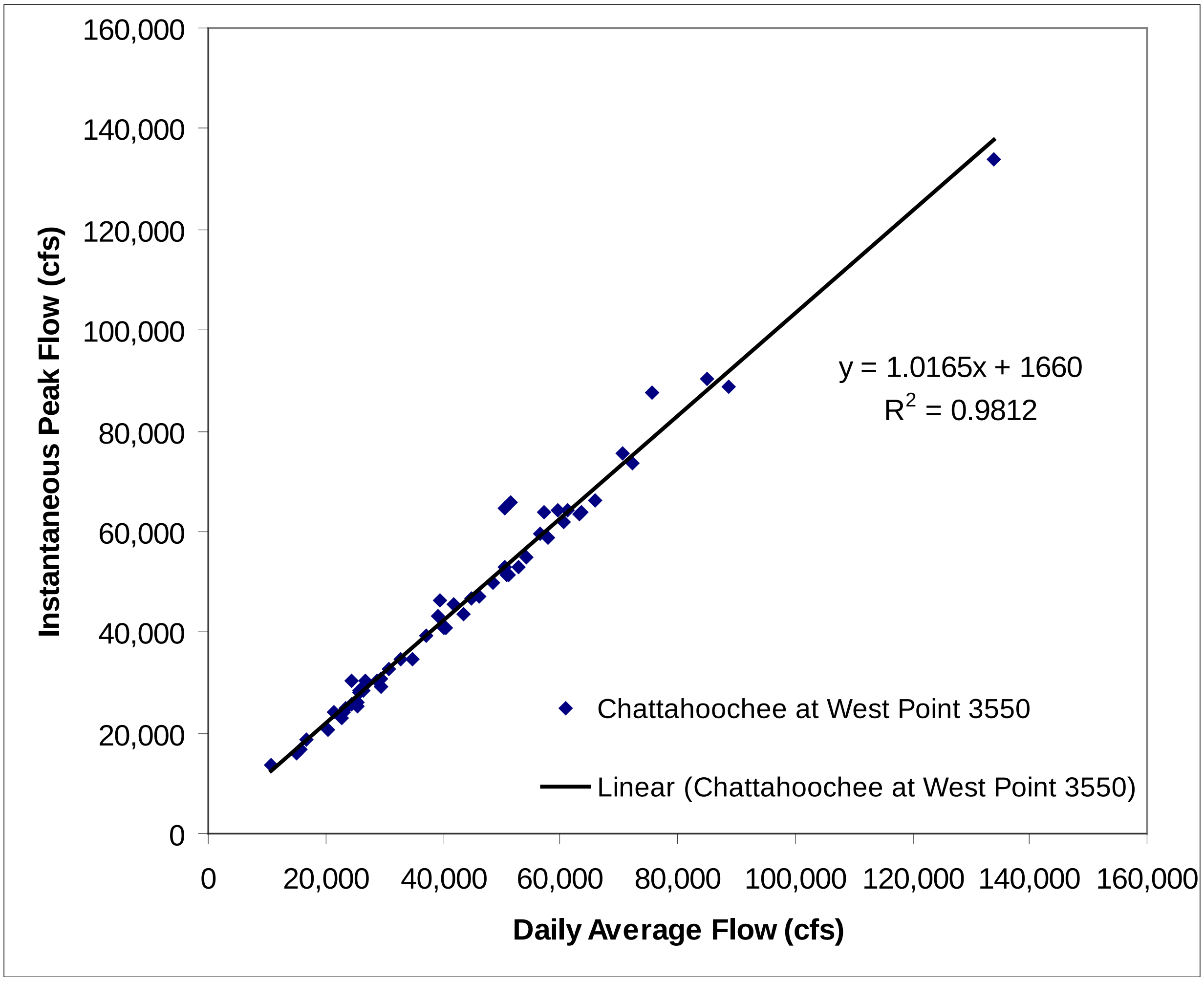

Figure I.07 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage (U.S. Army Corps of Engineers, 2009).

A Log-Pearson III flood frequency analysis was then conducted using HEC-SSP and the monthly maximum annual instantaneous discharges. Figures I.08 through I.19 show the flood frequency plots for each month.

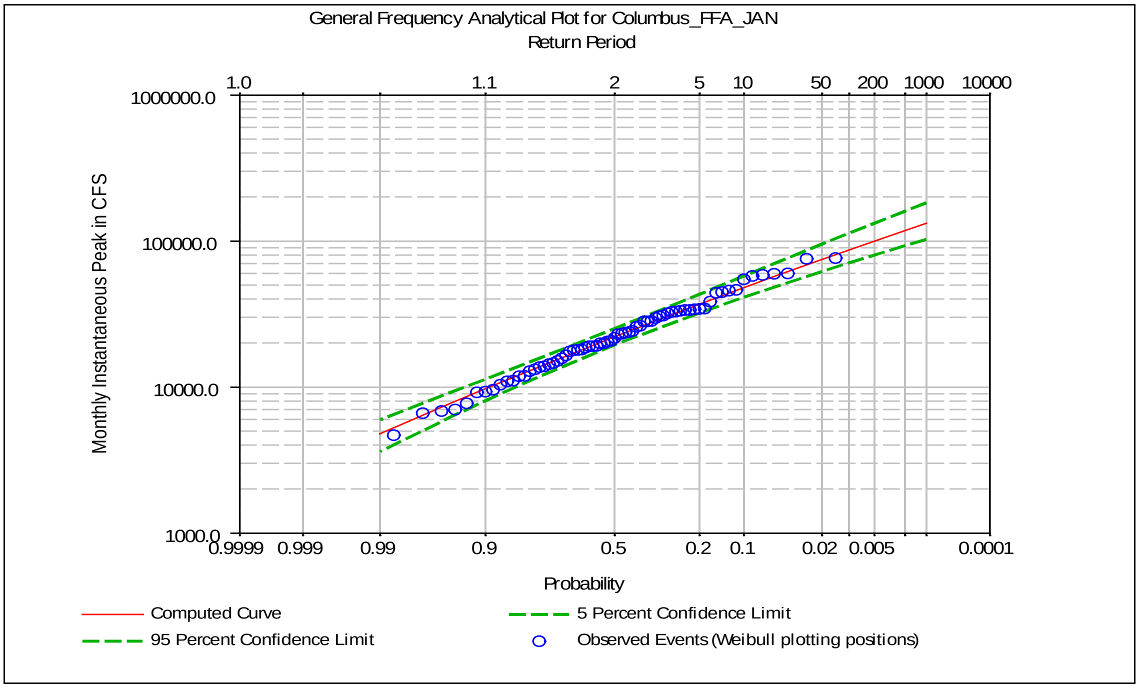

Figure I.08 January Unregulated Flood Frequency Curve

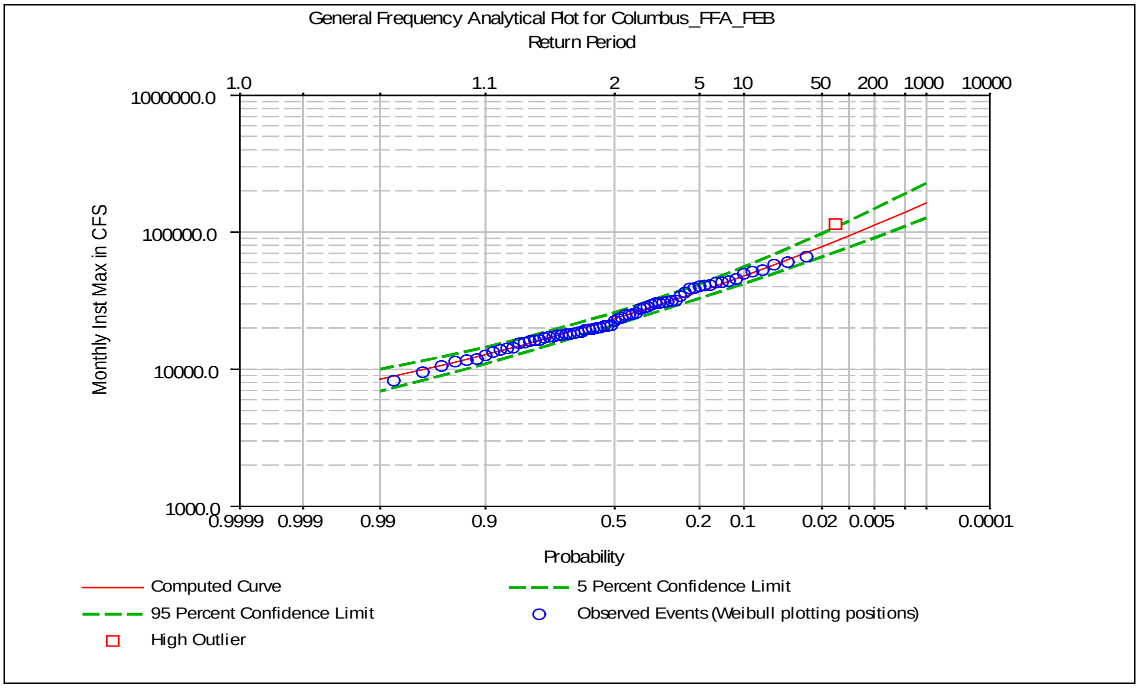

Figure I.09 February Unregulated Flood Frequency Curve

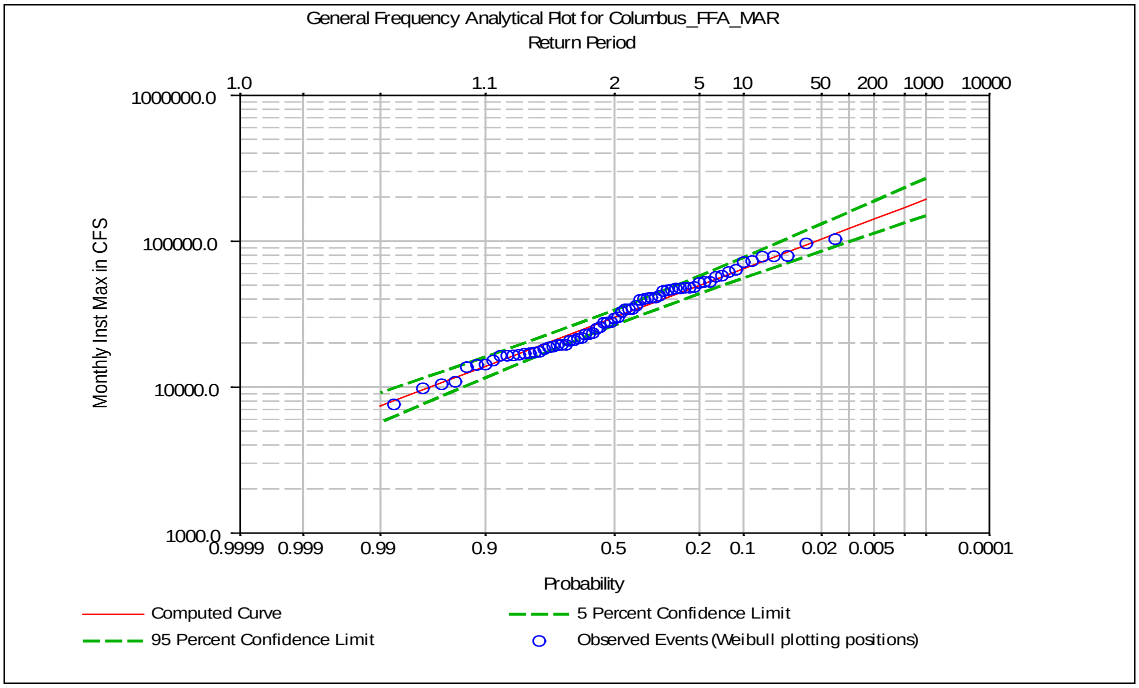

Figure I.10 March Unregulated Flood Frequency Curve

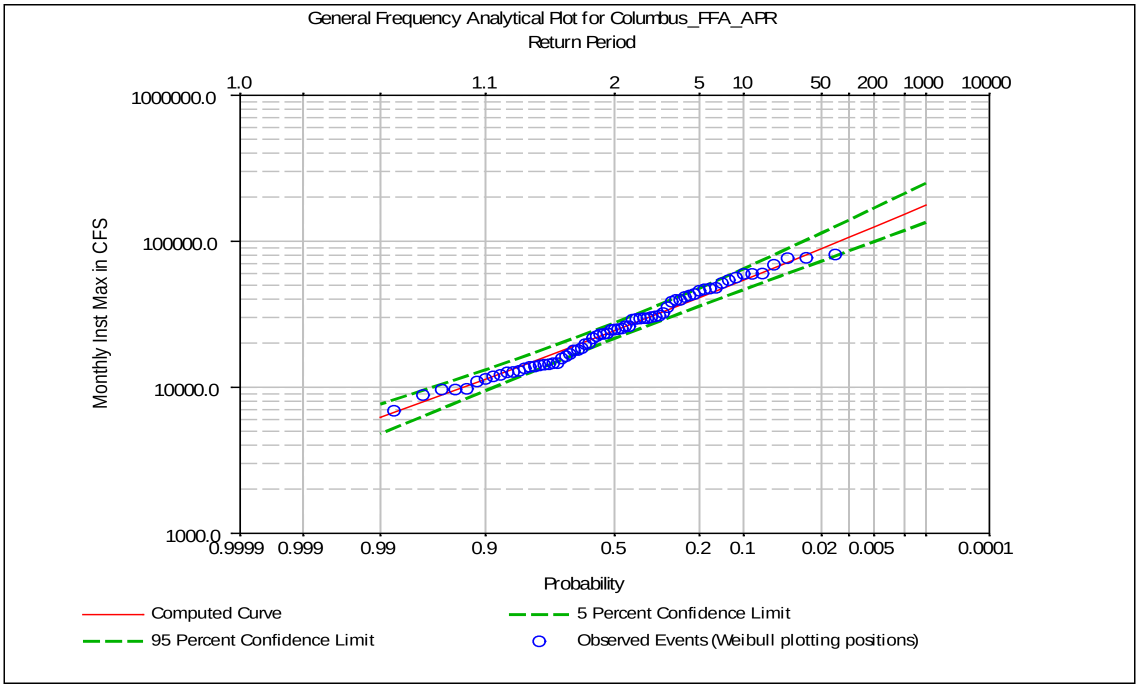

Figure I.11 April Unregulated Flood Frequency Curve

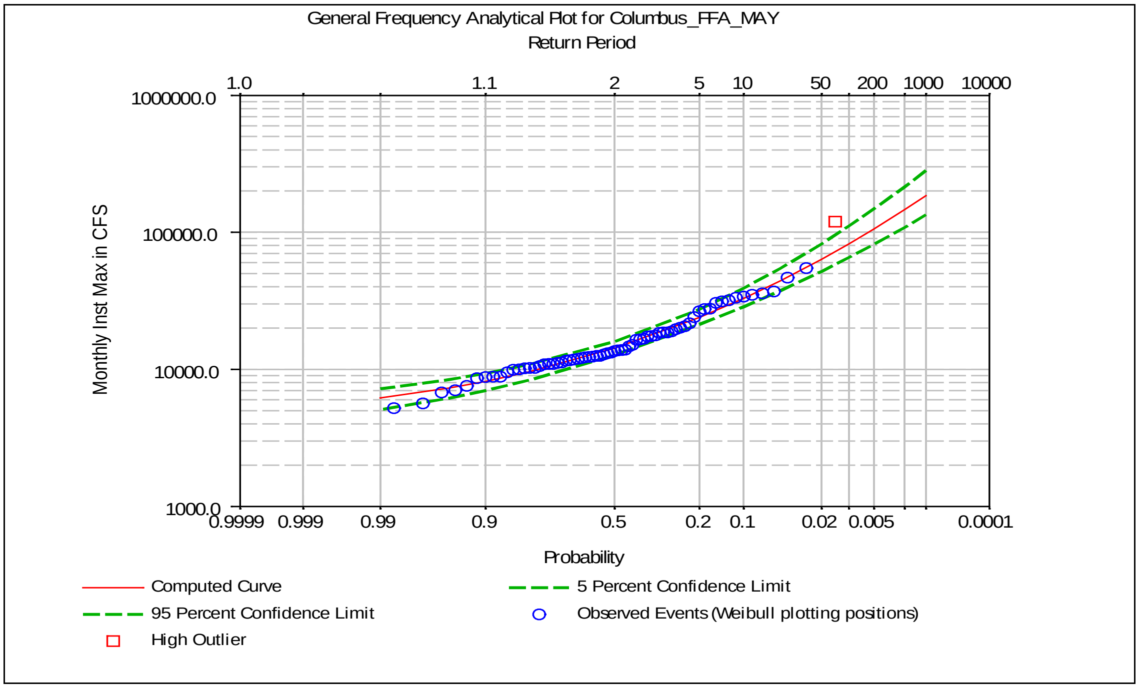

Figure I.12 May Unregulated Flood Frequency Curve

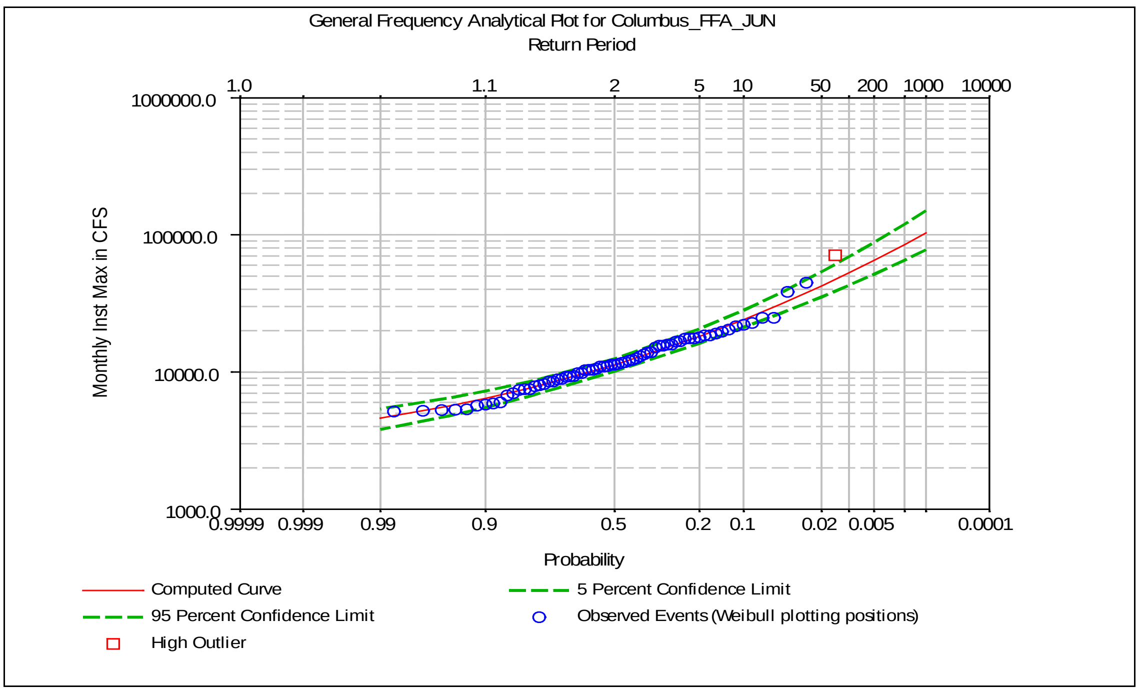

Figure I.13 June Unregulated Flood Frequency Curve

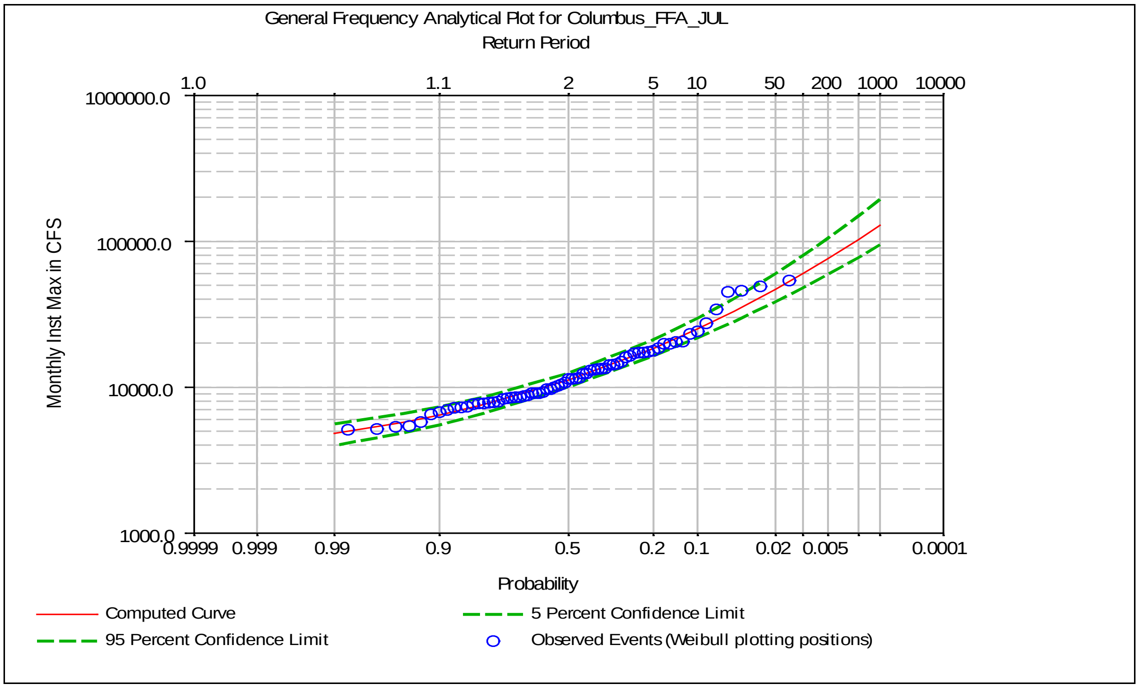

Figure I.14 July Unregulated Flood Frequency Curve

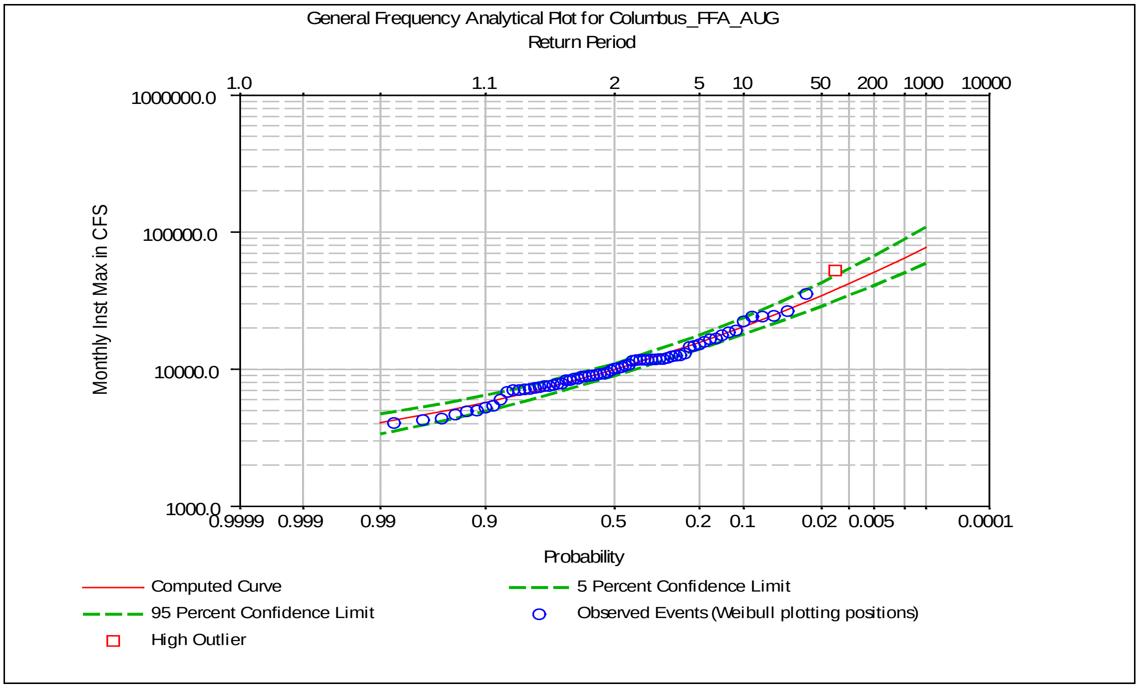

Figure I.15 August Unregulated Flood Frequency Curve

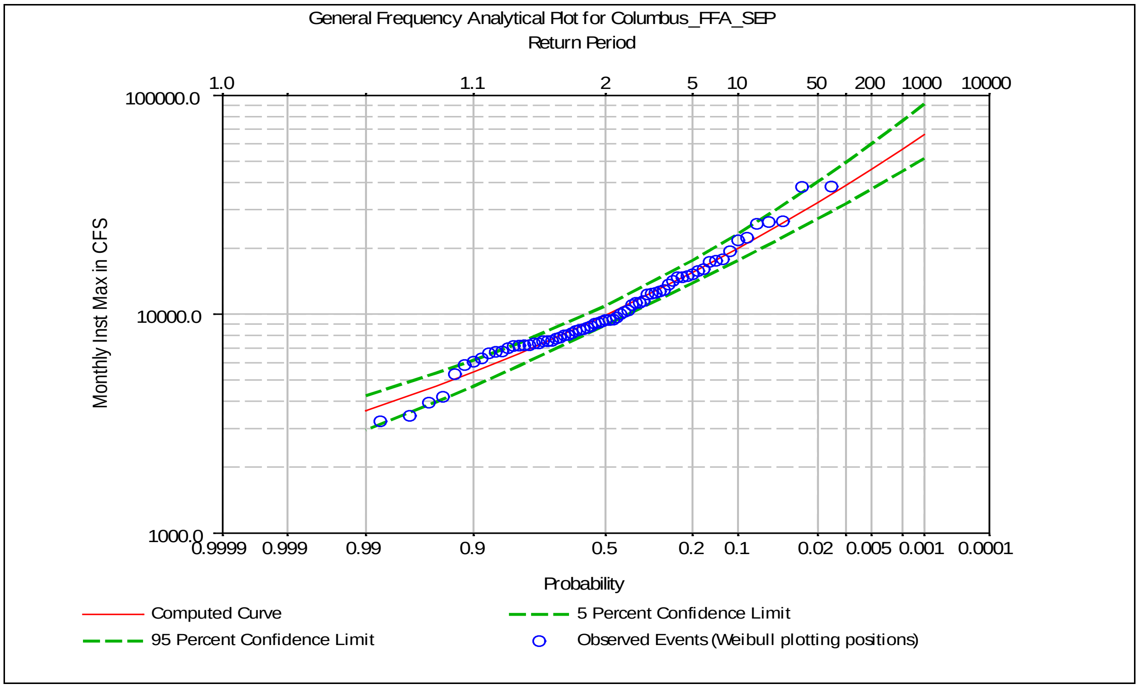

Figure I.16 September Unregulated Flood Frequency Curve

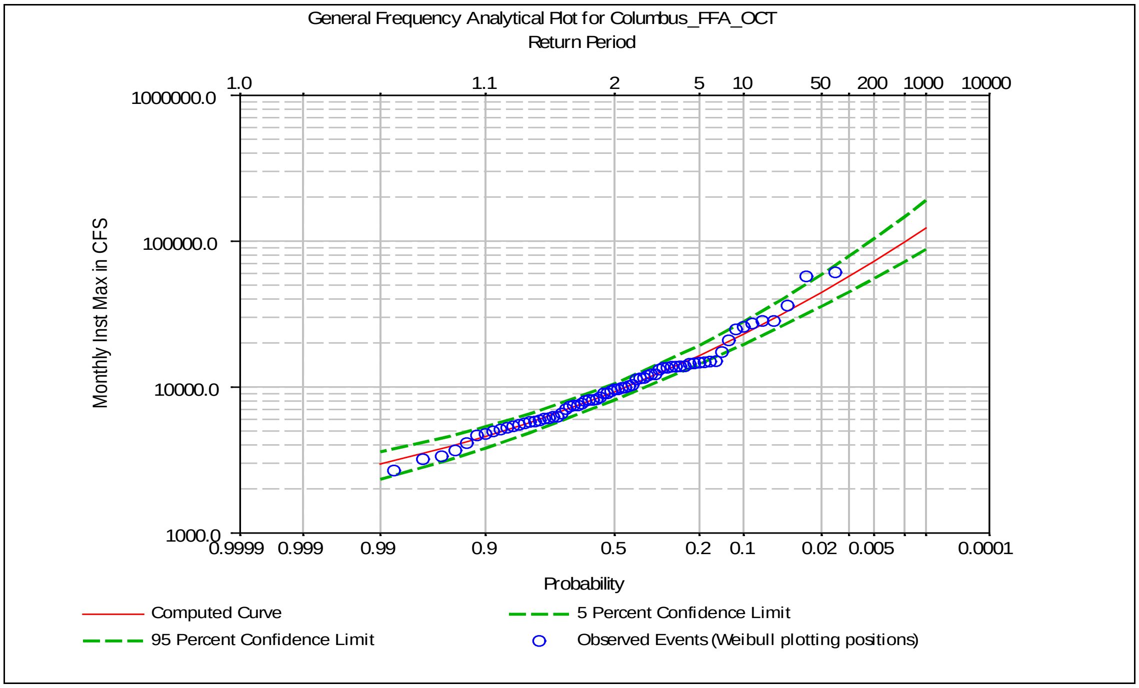

Figure I.17 October Unregulated Flood Frequency Curve

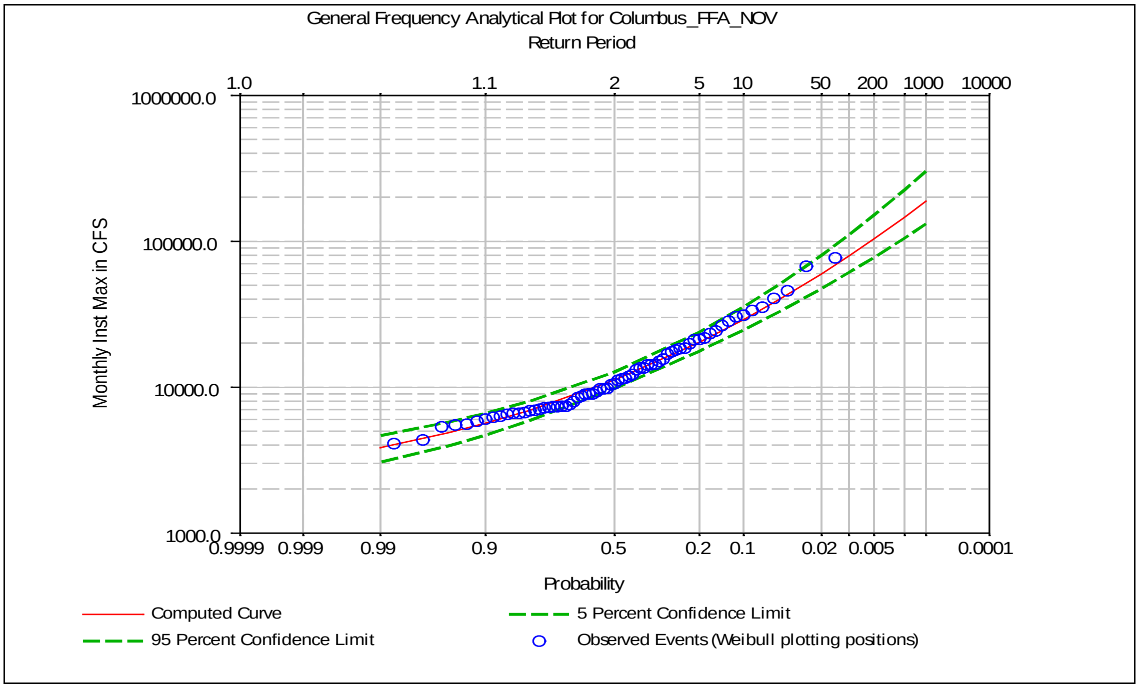

Figure I.18 November Unregulated Flood Frequency Curve

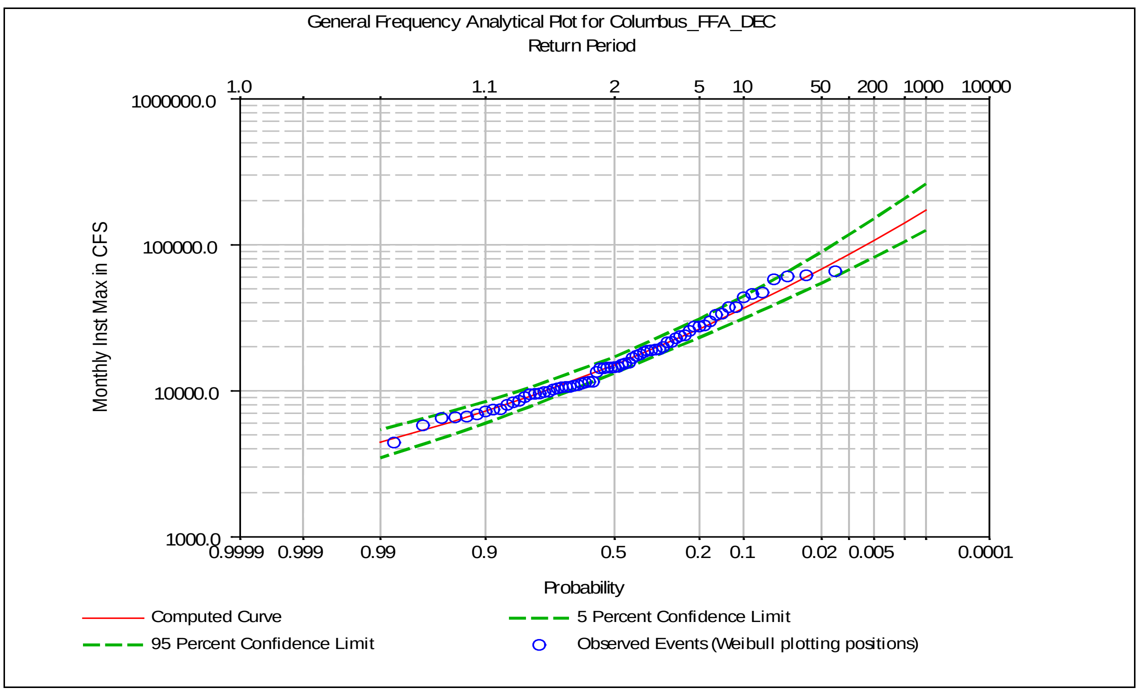

Figure I.19 December Unregulated Flood Frequency Curve

To determine the conditional exceedance probabilities of an overall hypothetical event occurring at a given month, 6 discharge values (160,000, 140,000, 120,000, 100,000, 80,000, and 60,000 cfs) were selected to represent the range of the regulated 5-, 2-, 1-, 0.5, and 0.2-percent flood frequency flows at Columbus. 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 I.08 through I.19. Table I.3 shows the conditional exceedance probabilities at each flow value.

Table I.3 Conditional Exceedance Probability for Each Month at Selected Flow Values

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
160000	0.00028	0.00111	0.00273	0.00161	0.00154	0.00018	0.00049	0.00004	0.00001	0.00041	0.00157	0.00130
140000	0.00069	0.00199	0.00527	0.00302	0.00227	0.00031	0.00076	0.00007	0.00002	0.00065	0.00226	0.00205
120000	0.00180	0.00383	0.01064	0.00598	0.00354	0.00057	0.00125	0.00015	0.00004	0.00108	0.00342	0.00345
100000	0.00498	0.00800	0.02267	0.01269	0.00588	0.00113	0.00219	0.00033	0.00012	0.00191	0.00550	0.00622
80000	0.01479	0.01860	0.05133	0.02920	0.01083	0.00249	0.00430	0.00086	0.00039	0.00378	0.00973	0.01241
60000	0.04757	0.05005	0.12401	0.07418	0.02328	0.00660	0.00995	0.00268	0.00155	0.00873	0.01976	0.02863

Table I.4 shows the normalized conditional exceedance probabilities. As expected, November 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 September, the conditional exceedance probability is the smallest.

Table I.4 Normalized Conditional Exceedance Probability for Each Month at Selected Flow Values

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
160000	2.5%	9.8%	24.2%	14.3%	13.7%	1.6%	4.3%	0.3%	0.1%	3.7%	13.9%	11.5%
140000	3.6%	10.3%	27.2%	15.6%	11.7%	1.6%	3.9%	0.4%	0.1%	3.4%	11.7%	10.6%
120000	5.0%	10.7%	29.8%	16.7%	9.9%	1.6%	3.5%	0.4%	0.1%	3.0%	9.6%	9.7%
100000	7.0%	11.2%	31.7%	17.7%	8.2%	1.6%	3.1%	0.5%	0.2%	2.7%	7.7%	8.7%
80000	9.3%	11.7%	32.3%	18.4%	6.8%	1.6%	2.7%	0.5%	0.2%	2.4%	6.1%	7.8%
60000	12.0%	12.6%	31.2%	18.7%	5.9%	1.7%	2.5%	0.7%	0.4%	2.2%	5.0%	7.2%

To check the representation of the monthly conditional exceedance probabilities, the number of annual peaks occurring in each month was counted using the unimpaired flow records at Columbus. The relative frequency was calculated as the number of annual peaks in each month divided by the total number of peaks. In general, the monthly distribution of the relative frequency in Table I.5 is similar to the one determined from the flood frequency analyses based on the monthly maximum instantaneous flows. However, use of the conditional exceedance probabilities in Table I.4 is preferable because (1) they were determined from flood frequency analyses using monthly peak flow records and (2) they have different probabilities for different magnitudes of flood events.

Table I.5 Relative Frequency for Each Month Based on Count of Annual Peaks

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of annual peaks	8	12	18	13	4	2	4	1	1	0	3	4
Relative exceedance probability	11.4%	17.1%	25.7%	18.6%	5.7%	2.9%	5.7%	1.4%	1.4%	0.0%	3%	4%

Note: The relative exceedance probability was calculated as the number of annual peak in each month divided by the total number of peaks.

E. Step 5 – Application of Total Probability Theorem

As discussed previously, the flood frequency flow at Columbus 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 I.20 shows an example of the calculation of the combined exceedance probability.

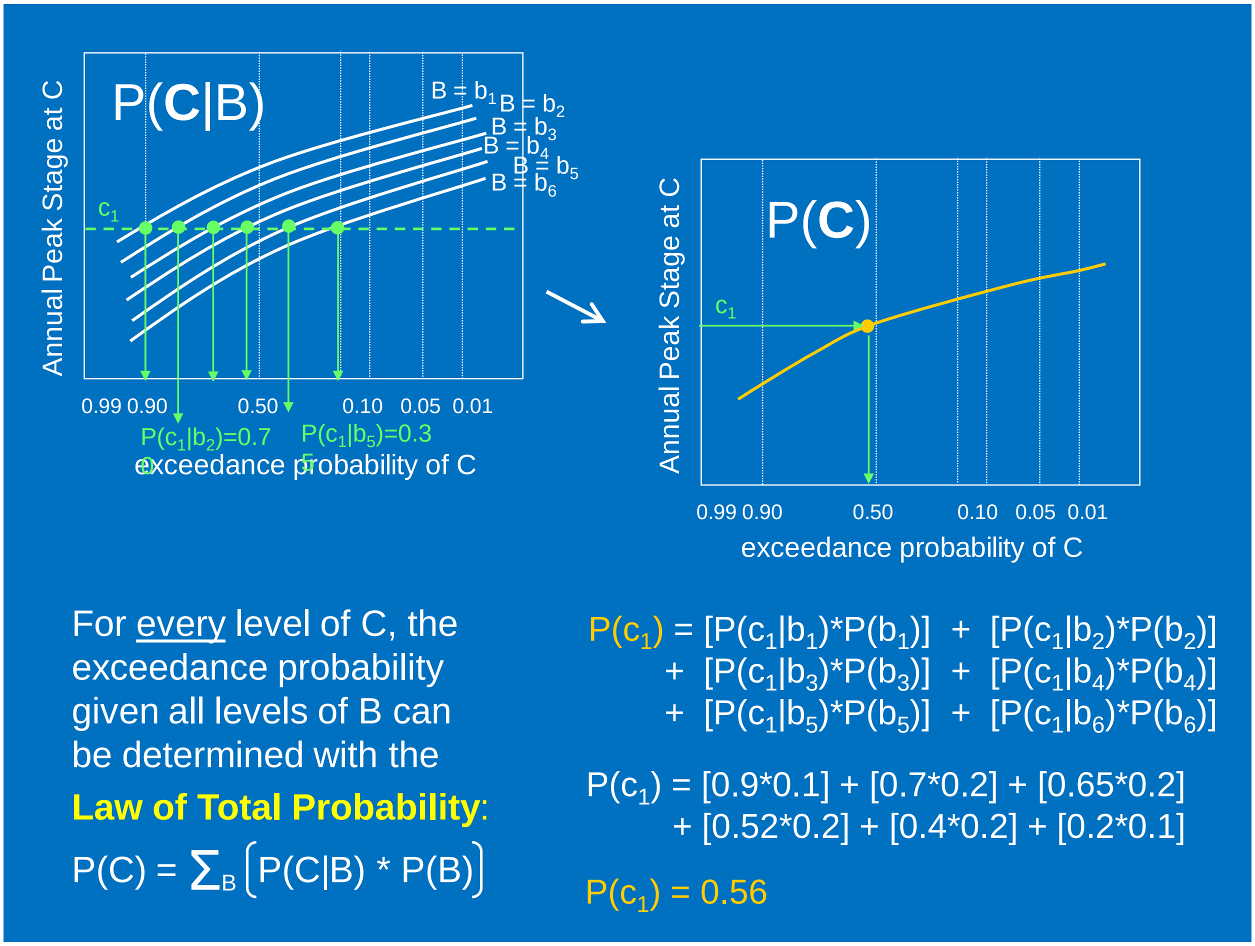

Figure I.20 Example of Total Probability Calculation

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. Table I.6 and Table I.7 show the values of the monthly exceedance probabilities of regulated flows based on the shapes of the March 1990 and May 2003 hydrograph shapes, respectively.

Table I.6 Exceedance Probabilities of Regulated Flood Flows Based on the Shapes of March 1990 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Condition												
160000	0.0003	0.0003	0.0006	0.0008	0.0011	0.0014	0.0014	0.0014	0.0014	0.0014	0.0008	0.0003
140000	0.0010	0.0010	0.0014	0.0019	0.0027	0.0034	0.0034	0.0033	0.0033	0.0033	0.0021	0.0010
120000	0.0032	0.0032	0.0038	0.0050	0.0069	0.0082	0.0083	0.0082	0.0082	0.0082	0.0054	0.0032
100000	0.0096	0.0097	0.0113	0.0131	0.0178	0.0217	0.0218	0.0216	0.0216	0.0216	0.0141	0.0096
80000	0.0198	0.0204	0.0272	0.0323	0.0405	0.0463	0.0465	0.0460	0.0461	0.0461	0.0343	0.0198
60000	0.0587	0.0584	0.0558	0.0722	0.0968	0.1063	0.1067	0.1057	0.1058	0.1058	0.0807	0.0587
Early Refill Condition												
160000	0.0003	0.0004	0.0007	0.0009	0.0014	0.0014	0.0014	0.0014	0.0011	0.0008	0.0007	0.0004
140000	0.0010	0.0012	0.0017	0.0022	0.0034	0.0034	0.0034	0.0033	0.0027	0.0020	0.0016	0.0011
120000	0.0032	0.0035	0.0042	0.0059	0.0082	0.0082	0.0083	0.0082	0.0069	0.0052	0.0039	0.0034
100000	0.0096	0.0105	0.0121	0.0151	0.0217	0.0217	0.0218	0.0216	0.0180	0.0137	0.0118	0.0103
80000	0.0198	0.0248	0.0289	0.0368	0.0462	0.0463	0.0465	0.0460	0.0406	0.0335	0.0281	0.0237
60000	0.0587	0.0566	0.0574	0.0920	0.1062	0.1063	0.1067	0.1057	0.0965	0.0779	0.0556	0.0572
Fall Stepped-down Condition												
160000	0.0003	0.0003	0.0006	0.0008	0.0011	0.0014	0.0014	0.0014	0.0010	0.0008	0.0008	0.0004
140000	0.0010	0.0010	0.0014	0.0019	0.0027	0.0034	0.0034	0.0033	0.0025	0.0021	0.0018	0.0012
120000	0.0032	0.0032	0.0038	0.0050	0.0069	0.0082	0.0083	0.0082	0.0066	0.0054	0.0045	0.0035
100000	0.0096	0.0097	0.0113	0.0131	0.0178	0.0217	0.0218	0.0216	0.0167	0.0140	0.0125	0.0105
80000	0.0198	0.0204	0.0272	0.0323	0.0405	0.0463	0.0465	0.0460	0.0392	0.0343	0.0300	0.0248
60000	0.0587	0.0584	0.0558	0.0722	0.0968	0.1063	0.1067	0.1057	0.0964	0.0813	0.0620	0.0568

Table I.7 Exceedance Probabilities of Regulated Flood Flows Based on the Shapes of May 2003 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Condition												
160000	0.0005	0.0005	0.0007	0.0009	0.0017	0.0027	0.0027	0.0027	0.0027	0.0027	0.0019	0.0007
140000	0.0010	0.0010	0.0013	0.0020	0.0034	0.0057	0.0058	0.0057	0.0057	0.0057	0.0039	0.0012
120000	0.0018	0.0018	0.0025	0.0044	0.0075	0.0120	0.0121	0.0119	0.0120	0.0120	0.0086	0.0025
100000	0.0038	0.0038	0.0054	0.0094	0.0169	0.0278	0.0279	0.0276	0.0277	0.0277	0.0194	0.0052
80000	0.0193	0.0193	0.0195	0.0267	0.0403	0.0642	0.0645	0.0638	0.0639	0.0639	0.0466	0.0194
60000	0.3201	0.3203	0.3204	0.1973	0.1040	0.1556	0.1561	0.1548	0.1550	0.1549	0.1187	0.3203
Early Refill Condition												
160000	0.0005	0.0006	0.0008	0.0013	0.0023	0.0027	0.0027	0.0027	0.0024	0.0014	0.0009	0.0007
140000	0.0010	0.0011	0.0016	0.0026	0.0047	0.0057	0.0058	0.0057	0.0049	0.0029	0.0018	0.0013
120000	0.0018	0.0021	0.0033	0.0058	0.0101	0.0120	0.0121	0.0119	0.0103	0.0064	0.0040	0.0025
100000	0.0038	0.0043	0.0071	0.0128	0.0237	0.0278	0.0279	0.0276	0.0243	0.0144	0.0086	0.0055
80000	0.0193	0.0193	0.0198	0.0349	0.0556	0.0642	0.0645	0.0638	0.0567	0.0368	0.0228	0.0195
60000	0.3201	0.3203	0.3204	0.1190	0.1378	0.1556	0.1561	0.1548	0.1395	0.1060	0.2542	0.3203
Fall Stepped-down Condition												
160000	0.0005	0.0005	0.0007	0.0009	0.0017	0.0027	0.0027	0.0027	0.0023	0.0013	0.0011	0.0007
140000	0.0010	0.0010	0.0013	0.0020	0.0034	0.0057	0.0058	0.0057	0.0047	0.0027	0.0024	0.0014
120000	0.0018	0.0018	0.0025	0.0044	0.0075	0.0120	0.0121	0.0119	0.0100	0.0059	0.0052	0.0028
100000	0.0038	0.0038	0.0054	0.0094	0.0169	0.0278	0.0279	0.0276	0.0235	0.0129	0.0113	0.0061
80000	0.0193	0.0193	0.0195	0.0267	0.0403	0.0642	0.0645	0.0638	0.0551	0.0351	0.0325	0.0196
60000	0.3201	0.3203	0.3204	0.1973	0.1040	0.1556	0.1561	0.1548	0.1364	0.1171	0.1380	0.3203

IV. Results of Combined Regulated Flood Frequency Curve

Using the procedure described in Step 5 and the exceedance probability values previously included in Table I.4, Table I.6, and Table I.7 for each selected flow values, the combined exceedance probability of the regulated flood flow was determined. Table I.8 and Table I.9 include the combined regulated 5-, 2-, 1-, 0.5-, and 0.2-percent flood flows.

Table I.8 Combined Regulated Flood Frequency Flows in cfs at Columbus Based on March 1990 Hydrograph Shapes

Exceedance Probability	Baseline	Early Refill	Fall Stepped-down	Change in percent from Baseline	
				Early Refill	Fall Stepped-down
0.002	137,824	139,323	137,173	1.1	-0.5
0.005	118,585	119,638	117,977	0.9	-0.5
0.01	104,709	105,766	104,274	1.0	-0.4
0.02	88,718	90,156	88,434	1.6	-0.3
0.05	66,700	67,800	66,259	1.6	-0.7

Table I.9 Combined Regulated Flood Frequency Flows in cfs at Columbus Based on May 2003 Hydrograph Shapes

Exceedance Probability	Baseline	Early Refill	Fall Stepped-down	Change in percent from Baseline	
				Early Refill	Fall Stepped-down
0.002	144,294	144,277	140,624	0.0	-2.5
0.005	117,713	118,586	114,682	0.7	-2.6
0.01	99,192	100,425	97,246	1.2	-2.0
0.02	85,755	86,342	84,455	0.7	-1.5
0.05	75,169	75,199	74,843	0.0	-0.4

Figure I.21 and Figure I.22 show the combined regulated flood frequency curves at Columbus. The results indicate that the Early Refill operation at West Point Dam will slightly increase the flood frequency flows at Columbus. The Fall Stepped-down operation will reduce the flood frequency flows at Columbus. In either case, the changes in the flood discharges from the Baseline condition are not significant.

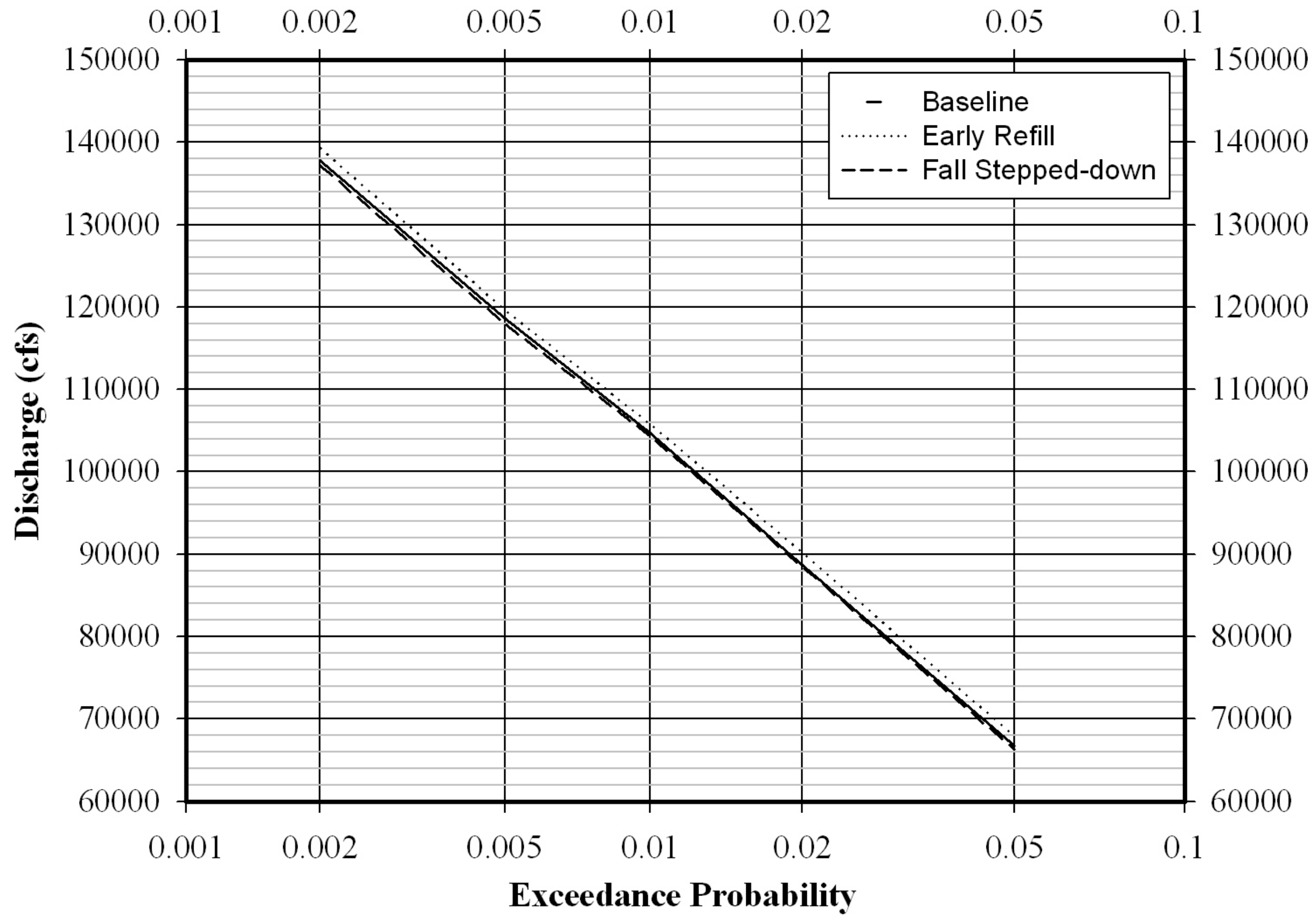

Figure I.21 Combined Flood Frequency Curves at Columbus Based on March 1990 Hydrograph Shapes

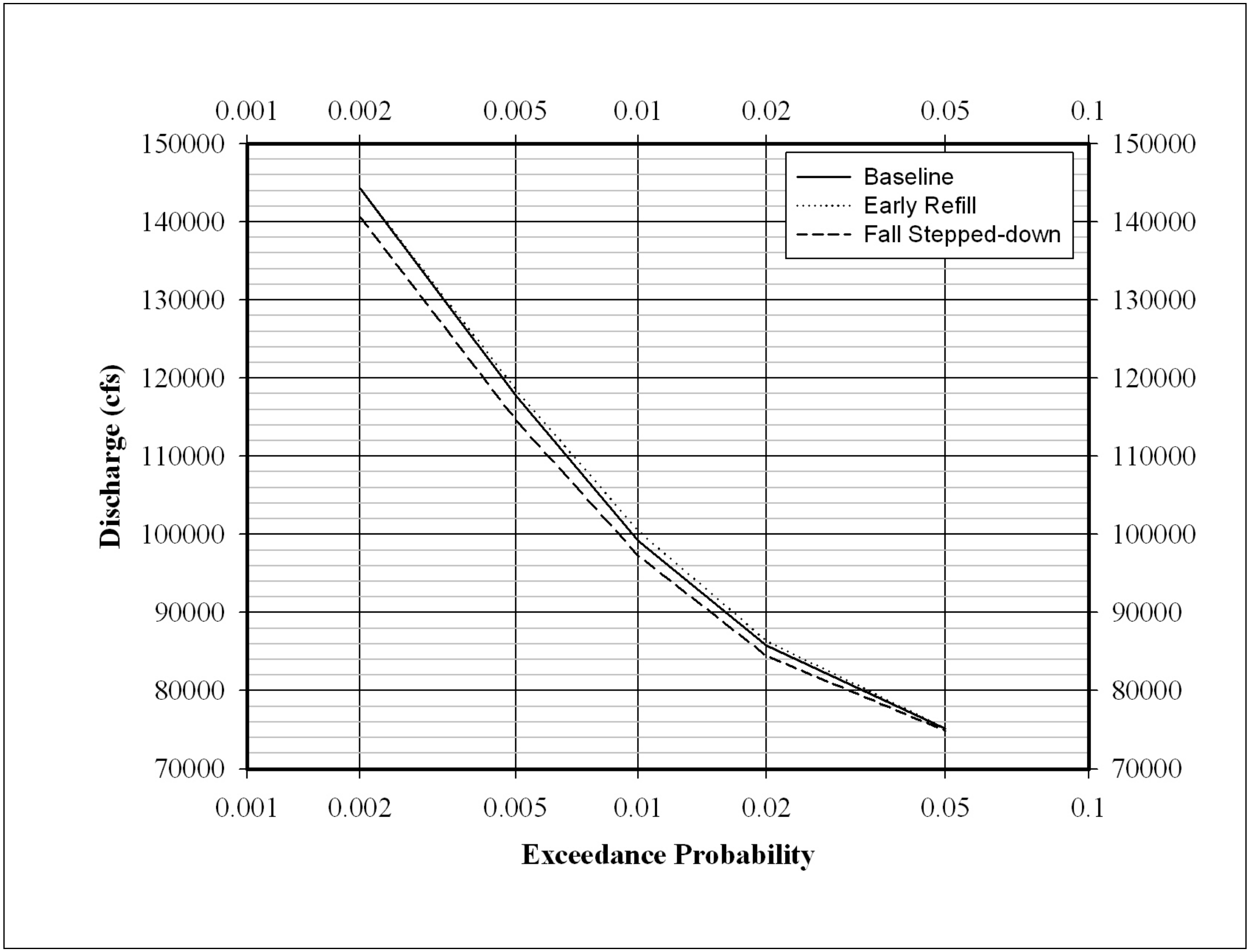

Figure I.22 Combined Flood Frequency Curves at Columbus Based on May 2003 Hydrograph Shapes

V. Appendix I - 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.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix J – Development of Sub-daily Flows from West Point to Columbus

August 2010

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Appendix J – Sub-daily Flow Development

DEVELOPMENT OF UNIMPAIRED HOURLY HYPOTHETICAL STORM HYDROGRAPHS FOR THE APALACHICOLA CHATTAHOOCHEE FLINT (ACF) RIVER SYSTEM FROM WEST POINT TO COLUMBUS

US Army Corps of Engineers
Mobile District

JULY 2009

Appendix J – Sub-daily Flow Development

Table of Contents:

List of Tables:

Appendix J-A Tables:

Appendix J-A Tables *(Continued)*:

Appendix J-B Tables:

Appendix J-D Tables:

List of Figures:

Appendix J-A Figures:

Appendix J-A Figures *(Continued)*:

Appendix J-B Figures:

Appendix J-C Figures:

Appendix J-D Figures:

Appendix J

Development of Sub-daily Flows from West Point to Columbus

1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE) Mobile District was tasked to develop unimpaired hourly hypothetical storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent chance exceedance events on the Apalachicola Chattahoochee Flint (ACF) River system from West Point Reservoir to Columbus, GA. The ACF River basin above Columbus, which is shown in Figure J.01 below, contains seven reservoirs and has a drainage area of approximately 4,670 square miles. Of the seven reservoirs on the ACF above Columbus, two are USACE projects and five are Georgia Power Company (GPC) projects.

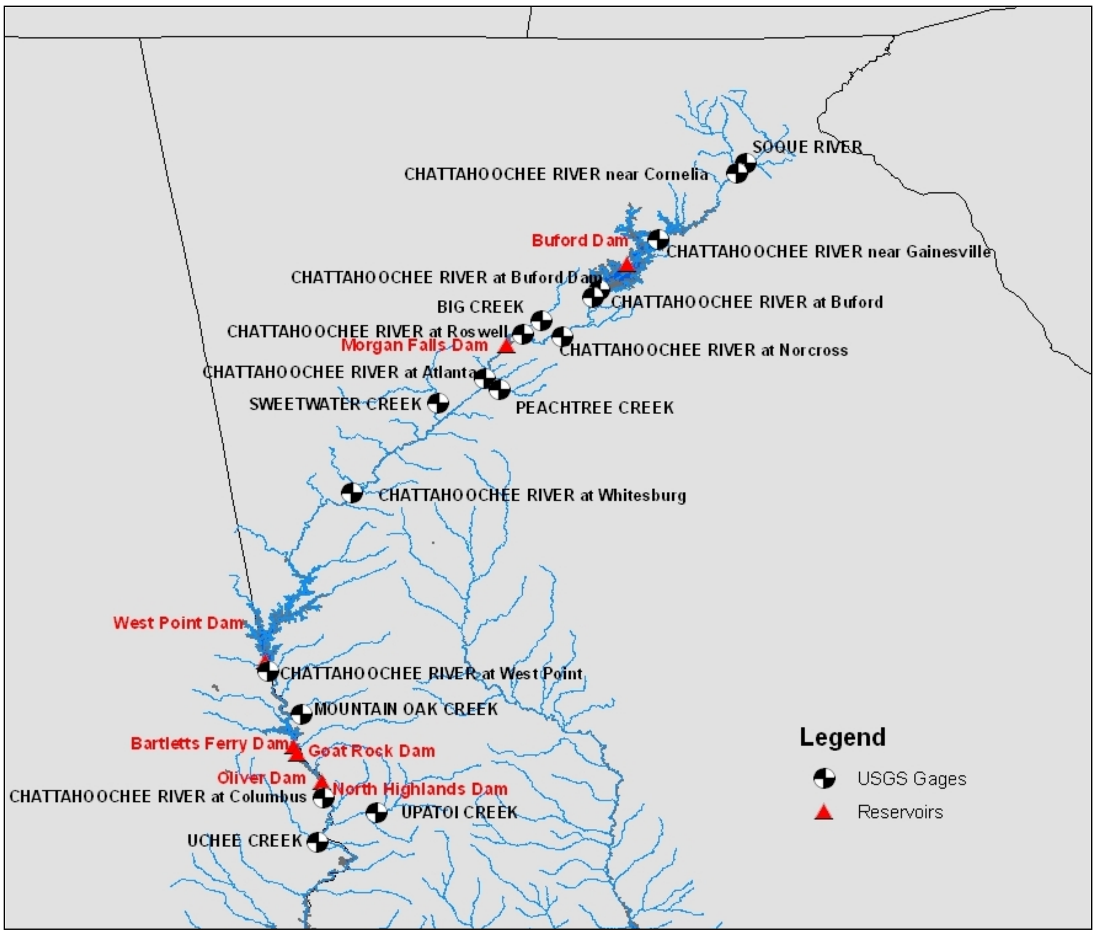

Figure J.01 ACF Basin above Columbus, GA.

The unimpaired hourly hypothetical hydrographs developed in this analysis were used as input to a reservoir system simulation (HEC-ResSim) model of the ACF River system from West Point Reservoir to Columbus. The HEC-ResSim model was used to analyze reservoir operations at West Point Dam during various hypothetical flood events and determine the downstream damages at Columbus, GA. There are seven points of interest or nodes from West Point Reservoir to Columbus in the HEC-ResSim model and they are shown in Figure J.02.

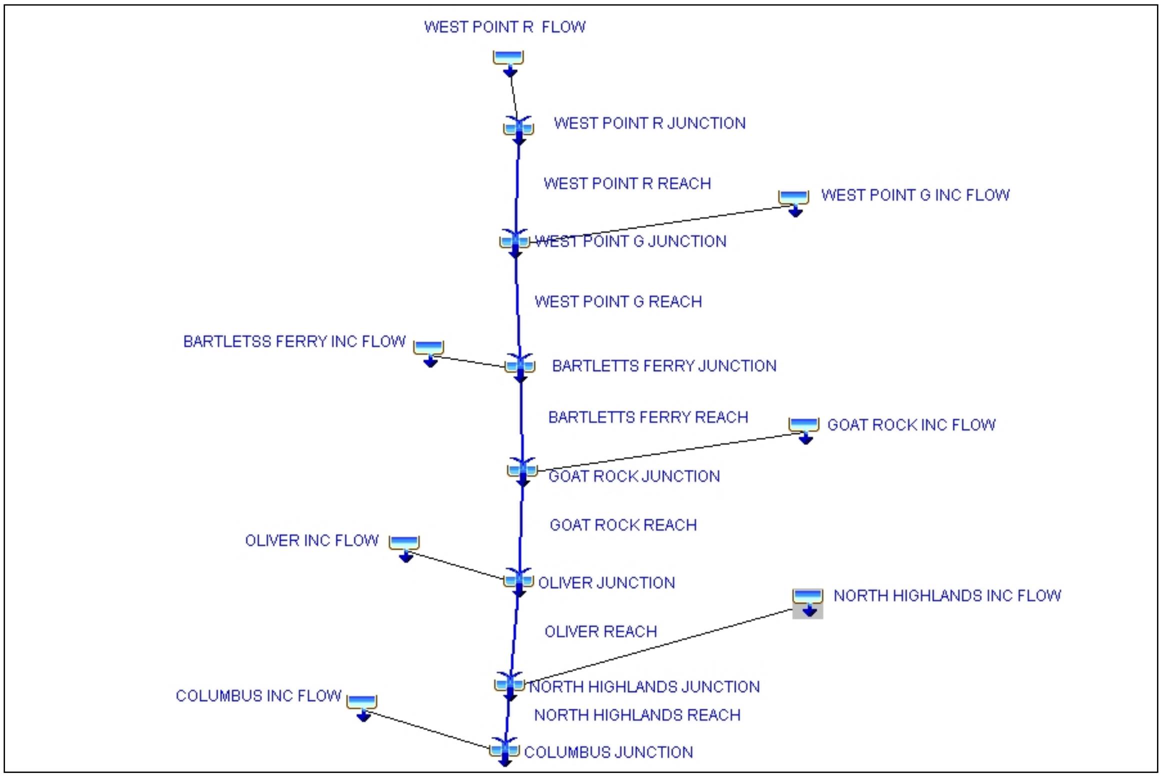

Figure J.02 ACF Model Node Schematic

In order to determine the hourly hypothetical storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events at the points of interest shown in Figure J.02, the USACE Mobile District and the USACE Hydrologic Engineering Center (HEC) developed a 6 step process. This process consisted of the following:

(1) Generate a daily vs. instantaneous peak flow relationship at points of interest the basin.
(2) Develop instantaneous, 1-, 3-, 5-, and 45-day peak flow frequency curves at Columbus. The 45-day frequency was selected in order to capture multiple peak events.
(3) Identify two historic storm events.
(4) Convert the daily unimpaired data to hourly for these two historic storm events.
(5) Develop and calibrate a HEC-HMS model.
(6) Scale the hourly data to produce the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events in the HMS model.

Additional details of this process are addressed in the following sections.

2. DEVELOPMENT OF HOURLY HYPOTHETICAL STORM HYDROGRAPHS

2.1 Development Instantaneous vs. Daily Peak Relationship

The first step in development of the hourly hypothetical unimpaired flow storm hydrographs was to generate an instantaneous vs. daily peak relationship at all USGS gages above Columbus. This analysis was performed by HEC staff and the details are provided in Appendix J-A. An example of the instantaneous vs. daily average flow correlation is shown in Figure J.03 for the West Point gage.

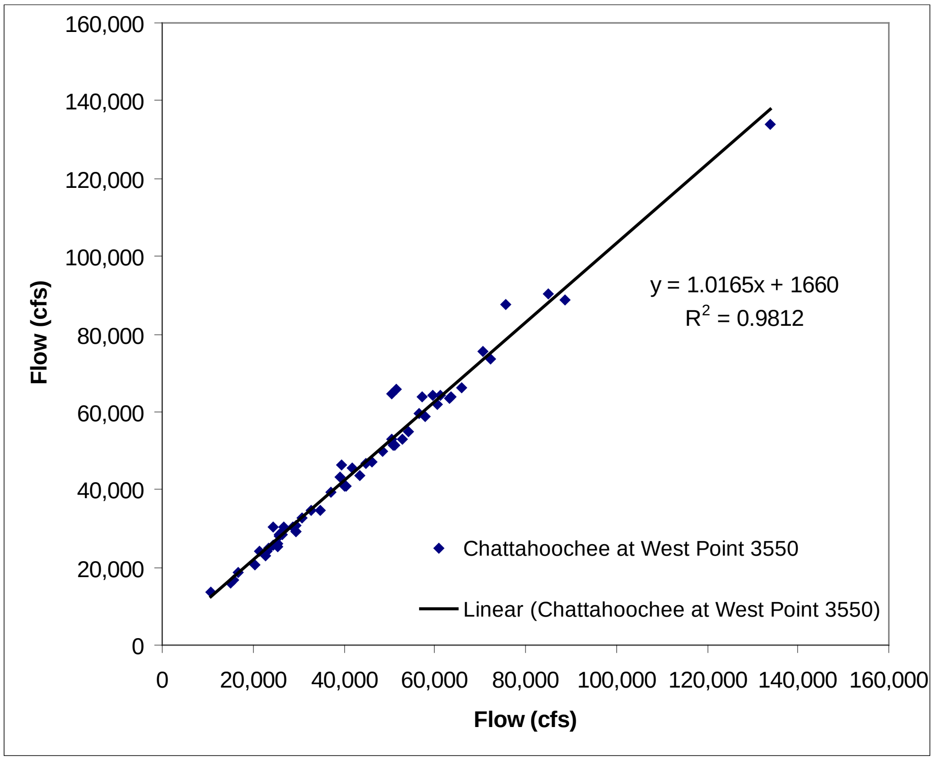

Figure J.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

2.2 Development of Unimpaired Flow Frequencies at Columbus

The second step in development of the hourly hypothetical unimpaired flow storm hydrographs was to compute the instantaneous, 1-, 3-, 5-, and 45-day unimpaired peak flow frequencies at Columbus. The instantaneous, 1-, 3-, 5-, and 45-day unimpaired peak flow frequencies were computed by HEC staff and are shown in Table J-01 below. Details of this analysis are provided in Appendix J-B of this report.

Table J-01. Unimpaired Flow Frequencies at Columbus

Frequency	Peak	1-Day	3-Day	5-Day	45-Day
99.0	18213	17286	15251	13501	5891
95.0	25156	23875	20851	18136	7774
90.0	29729	28216	24547	21180	8973
80.0	36220	34377	29810	25506	10630
50.0	52101	49449	42801	36171	14520
20.0	73577	69833	60666	50887	19518
10.0	87490	83037	72432	60634	22638
5.0	100571	95453	83633	69962	25506
2.0	117185	111221	98050	82044	29071
1.0	129461	122872	108840	91143	31656
0.5	141594	134388	119616	100280	34176
0.2	157511	149495	133923	112487	37434
0.1	169509	160883	144831	121852	39857

2.3 Identification of Historic Flood Events

The third step in development of the hourly hypothetical unimpaired flow storm hydrographs was to identify two historic storm events from the daily average unimpaired data set. The two historic storms identified for use in this analysis were the March 1990 and May 2003 events. These storms were selected from the period of record because of their high 45-day volume and peaks. The daily average unimpaired flow hydrographs for the two events at Columbus, GA are shown in Figure J.04 and Figure J.05. The March 1990 and May 2003 events are approximately the 3.8-percent and 1.3-percent chance exceedance events at Columbus respectively.

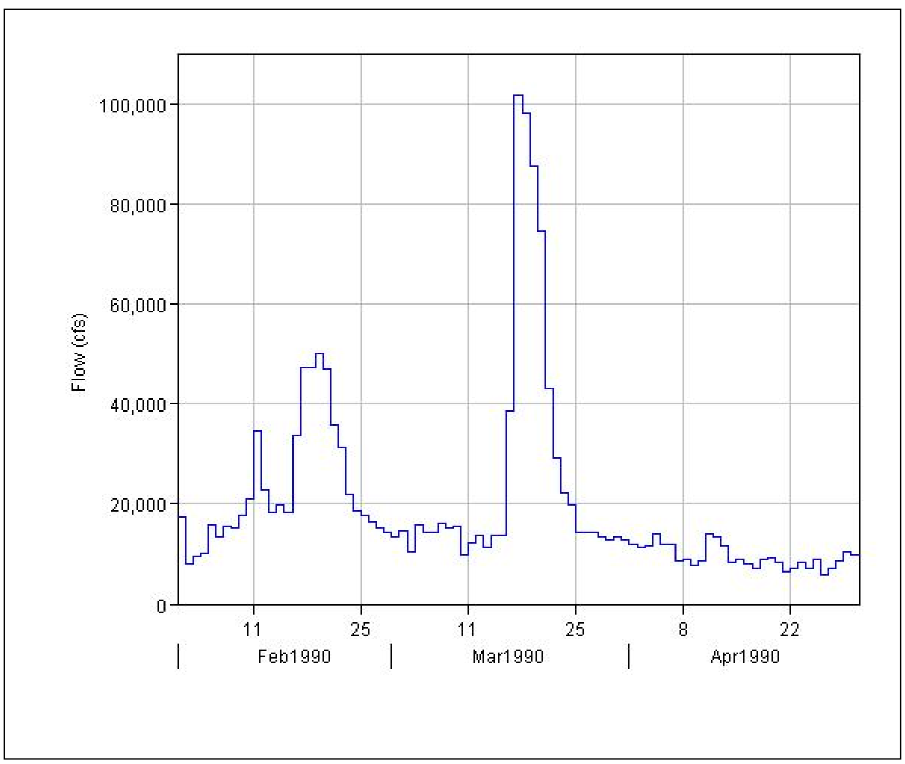

Figure J.04 March 1990 Flood Event at Columbus, GA

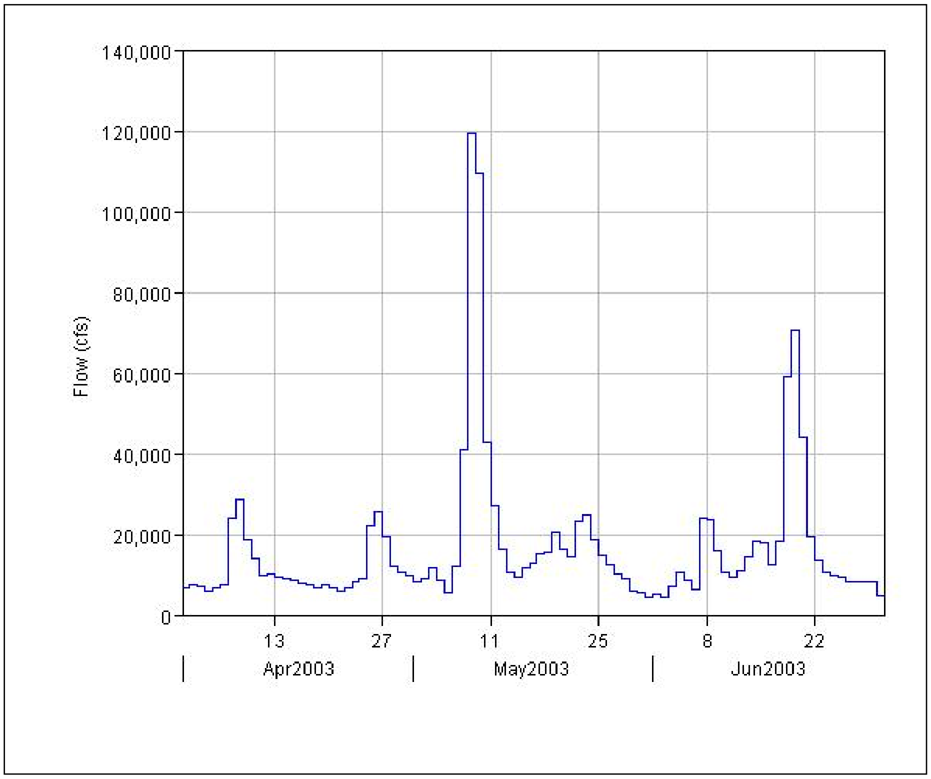

Figure J.05 May 2003 Flood Event at Columbus, GA

2.4 Conversion of Daily Average Unimpaired Data to Hourly Values

The fourth step in the development of the hourly hypothetical unimpaired flow storm hydrographs was to convert the March 1990 and May 2003 flood events from daily average flows to hourly flows. The hourly flows for the March 1990 and May 2003 events were developed by the Mobile District and HEC staff respectively. The daily and hourly hydrographs for the two flood events at Columbus are shown in Figure J.06 and Figure J.07. Notice that only the largest flood hydrographs were converted to a “true” hourly hydrographs. The hourly flows for the rest of the time window were computed by interpolating the daily average flows. Details of the daily to hourly conversion are provided in Appendix J-C.

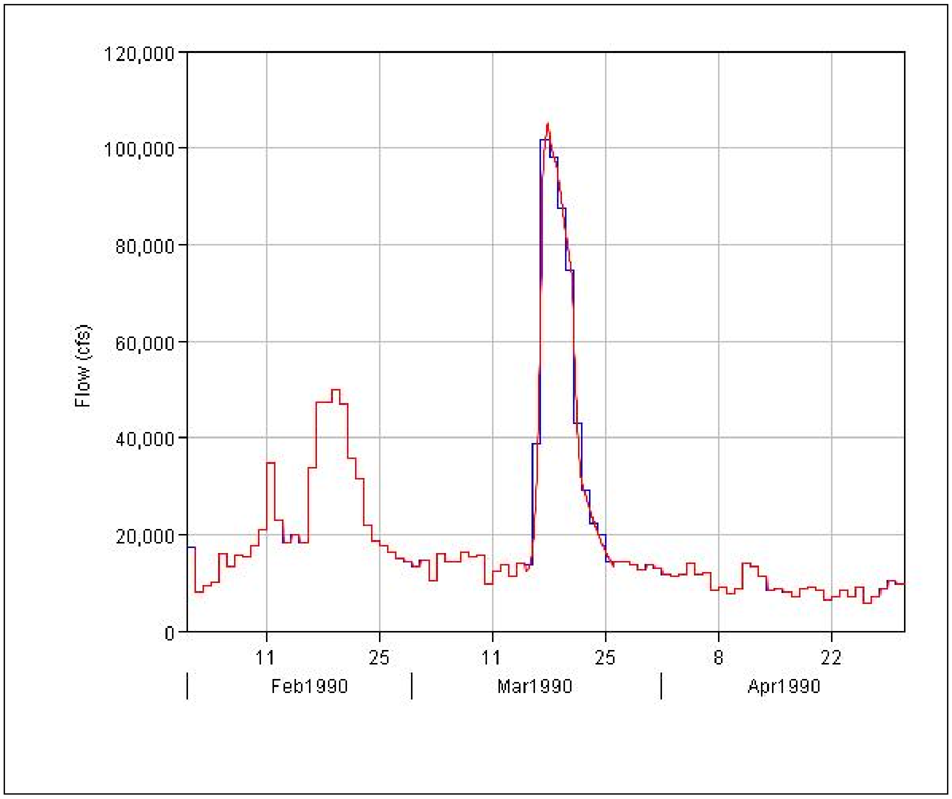

Figure J.06 March 1990 Daily vs. Hourly Flow Hydrographs at Columbus

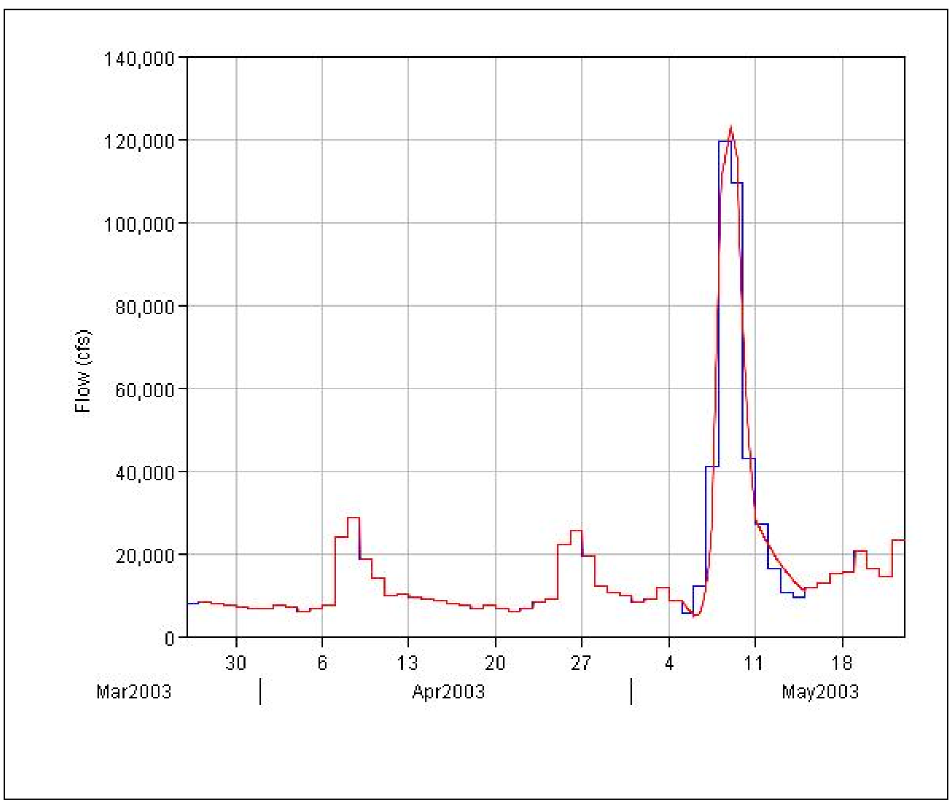

Figure J.07 May 2003 Daily vs. Hourly Flow Hydrographs at Columbus

2.5 Development and Calibration of HEC-HMS Model

The fifth step in the development of the hourly hypothetical unimpaired flow storm hydrographs was to develop a calibrated HMS model of the basin above Columbus. The HEC-HMS model results for the March 1990 and May 2003 storm events at Columbus are shown in Figure J.08 and Figure J.09. Details of the development and calibration of the HEC-HMS model are outlined in Appendix J-D.

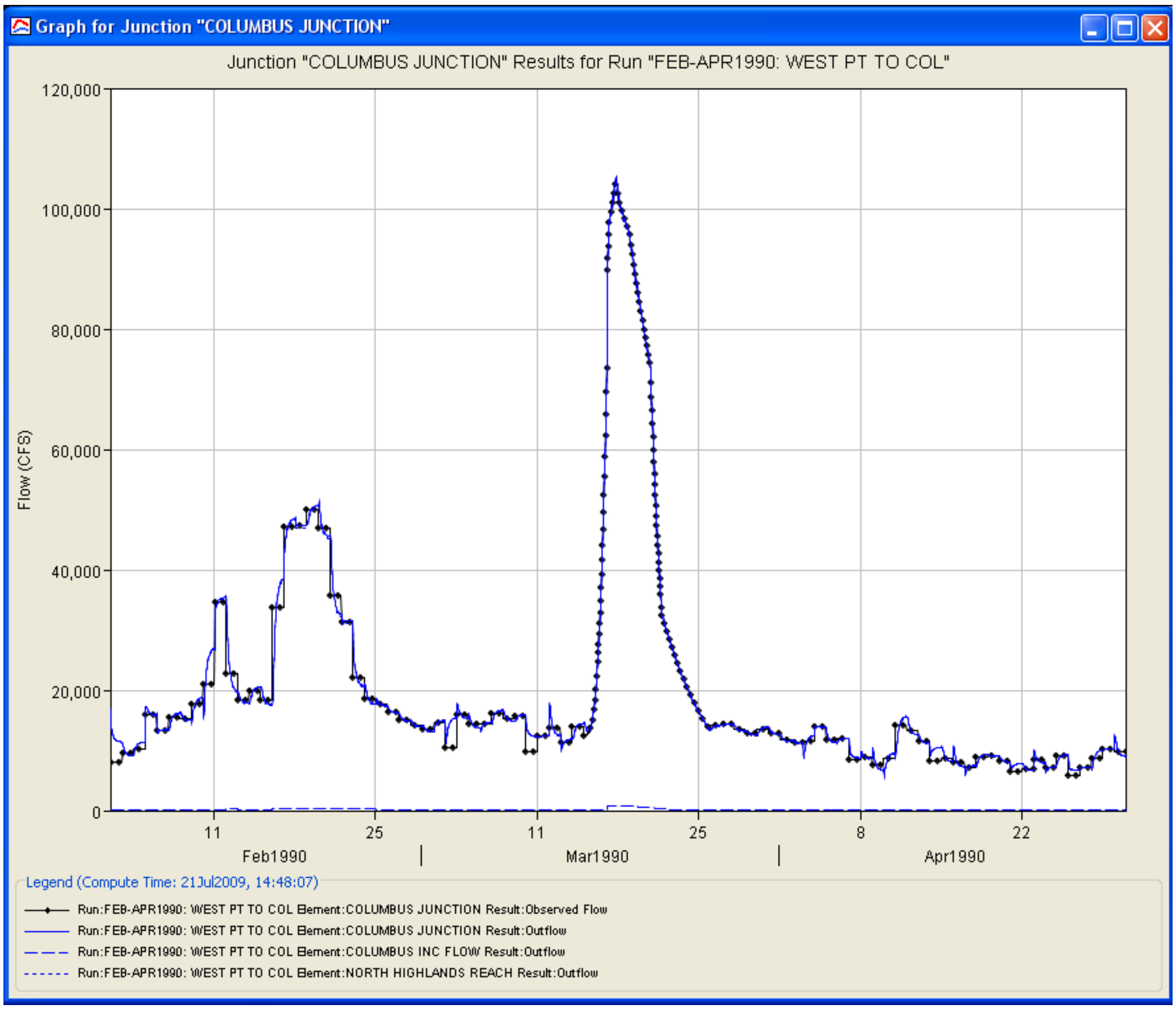

Figure J.08 HEC-HMS Model Results for the March 1990 Storm Event

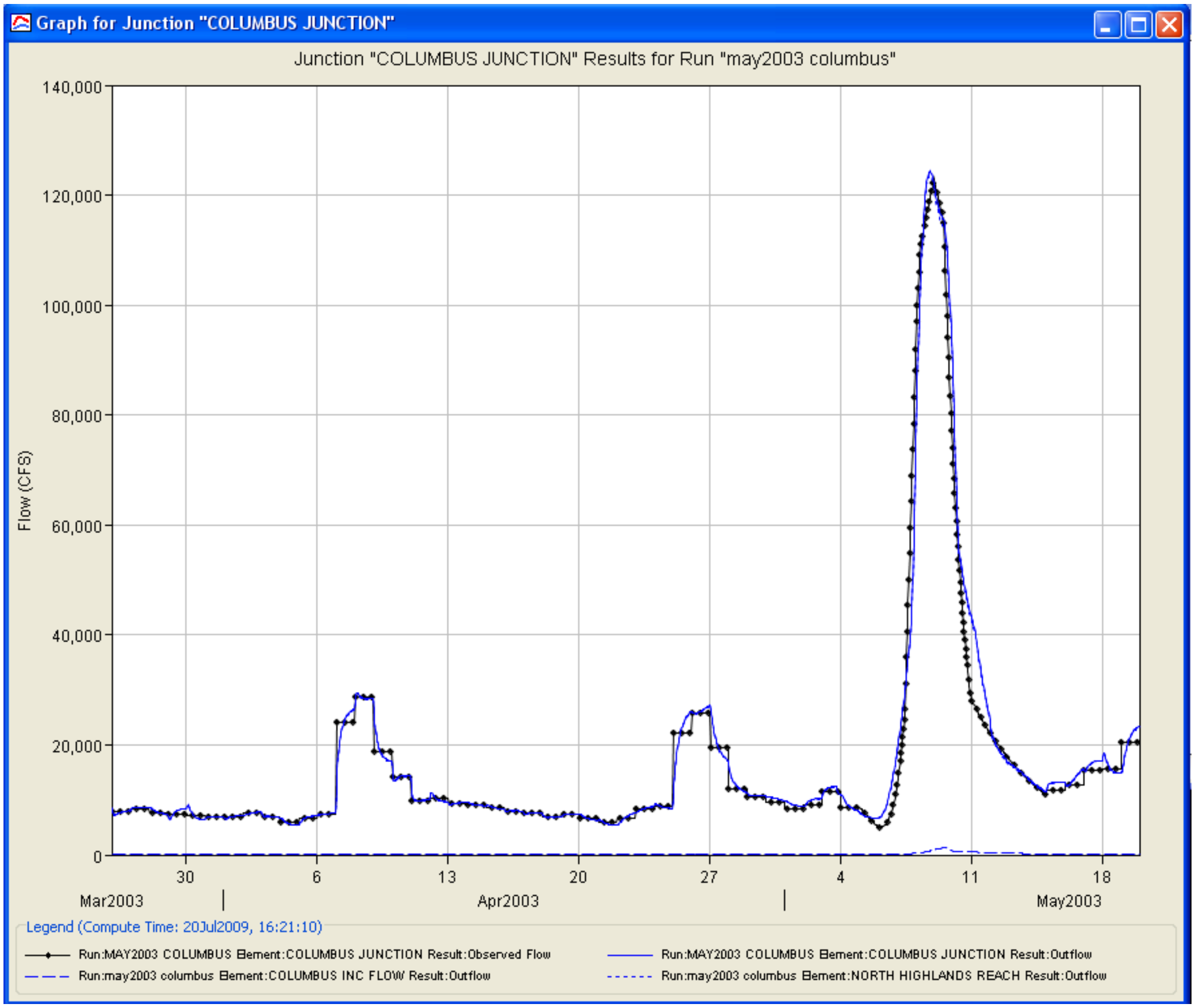

Figure J.09 HEC-HMS Model Results for the May 2003 Storm Event

2.6 Development of the Hourly Unimpaired Hypothetical Design Storms

The sixth step in the development of the hourly hypothetical unimpaired flow storm hydrographs was to scale the hourly data to produce the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events in the HMS model. This step was completed by:

(1) scaling the hourly unimpaired data at Columbus for the March 1990 and May 2003 events to match the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance flows from Section 2.2,
(2) using the same scaling factor to scale all the local flow and inflow sources upstream of Columbus, and
(3) routing the scaled flows through the calibrated HEC-HMS models to produce the 5-, 2-, 1-, 0.5-, and 0.2-percent flows at Columbus.

The HMS hydrographs at Columbus were compared to the computed unimpaired hourly instantaneous, 1-, 3-, 5-, and 45-day peak flow volumes at Columbus to ensure that the percent differences were within ten percent. If the HMS hourly hydrographs were not within ten percent of the computed hourly unimpaired hydrographs, the local flows were adjusted and the flow at Columbus was recomputed with HMS.

2.6.1 Scaling the Hourly Flows at Columbus

The hourly unimpaired storm hydrographs for the March 1990 and May 2003 events at Columbus are shown in Table J-01. The scaling factors for the March 1990 and May 2003 events are shown in Table J-02. The peak hourly unimpaired flows for the March 1990 and May 2003 events were 105,163 cfs and 122,951 cfs respectively.

Table J-02. Scaling Factors for the March 1990 and May 2003 Events

Percent Chance Exceedance Event	Flow (cfs)	March 1990 Scaling Factors	May 2003 Scaling Factors
5	100,571	0.956	0.818
2	117,185	1.114	0.953
1	129,461	1.231	1.053
0.5	141,594	1.346	1.152
0.2	157,511	1.498	1.281

2.6.2 Scaling the Hourly Local Flows

The hourly unimpaired local flow and inflow sources above Columbus were scaled for the March 1990 and May 2003 events using the scaling factors provided in Table J-02.

2.6.3 Routing the Scaled Flows through the HEC-HMS Model to Determine the Hourly Unimpaired Hypothetical Flow Hydrographs

The scaled hourly unimpaired local flow and inflow sources were input into the calibrated HEC-HMS models for the March 1990 and May 2003 events. The HMS models were then used to combine and route the flows downstream to produce the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance event peak flows at Columbus. The instantaneous, 1-, 3-, 5-, and 45-day peak flow volumes from the HMS hydrographs at Columbus were compared to those shown in Table J-01. The local flow and inflow source hydrographs for the March 1990 event had to be adjusted by a factor of 0.85 for the portion of the storm event from February 02, 1990 to March 25, 1990 in order to reduce the 5-day and 45-day volumes to within ten percent of those provided in Table 1. For the March 2003 event, three adjustments were made for each frequency event to reduce the 1-, 3-, 5-, and 45-day peak flow volumes to within ten percent of those provided in Table J-01. These adjustment factors are shown in Table J-03. Factor 1 was used from March 01, 2003 to April 25, 2003. Factor 2 was used from April 25, 2003 to May 06, 2003. Factor 3 was used from May 06, 2003 to May 18, 2003. The 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance event HMS unimpaired hourly flow hydrographs at Columbus for the March 1990 and May 2003 events are shown in Figure J.10 and Figure J.11. A summary of the data is provided in Table J-04 and Table J-05.

Table J-03. Adjustment Factors for the May 2003 Event

Adjustment Factor	Percent Chance Exceedance				
	5	2	1	0.5	0.2
1	1.400	1.500	1.750	1.750	2.000
2	2.250	2.600	2.600	3.000	3.000
3	0.756	0.881	0.972	1.064	1.185

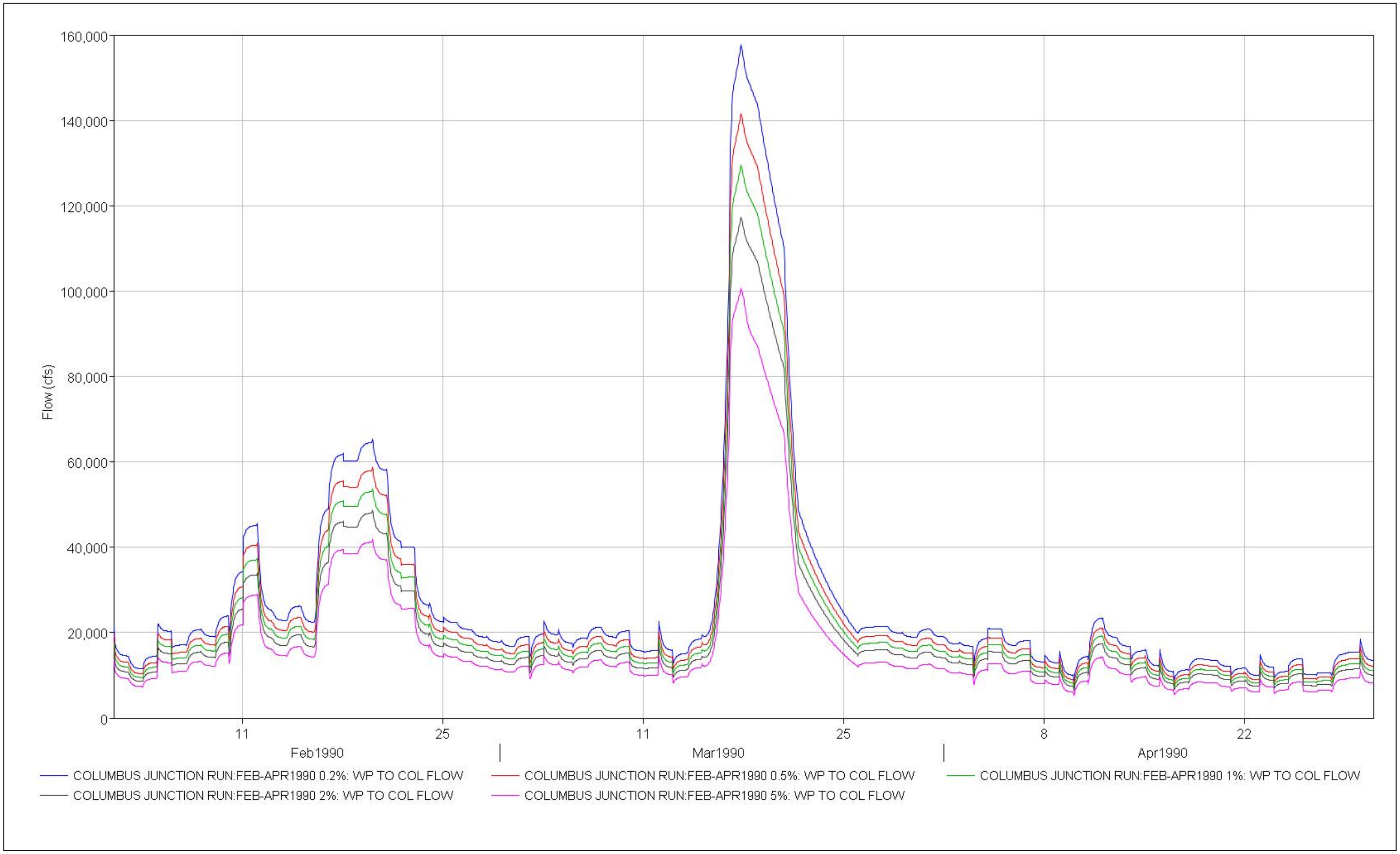

Figure J.10 HEC-HMS Hourly Unimpaired Hypothetical Hydrographs for the March 1990 Event

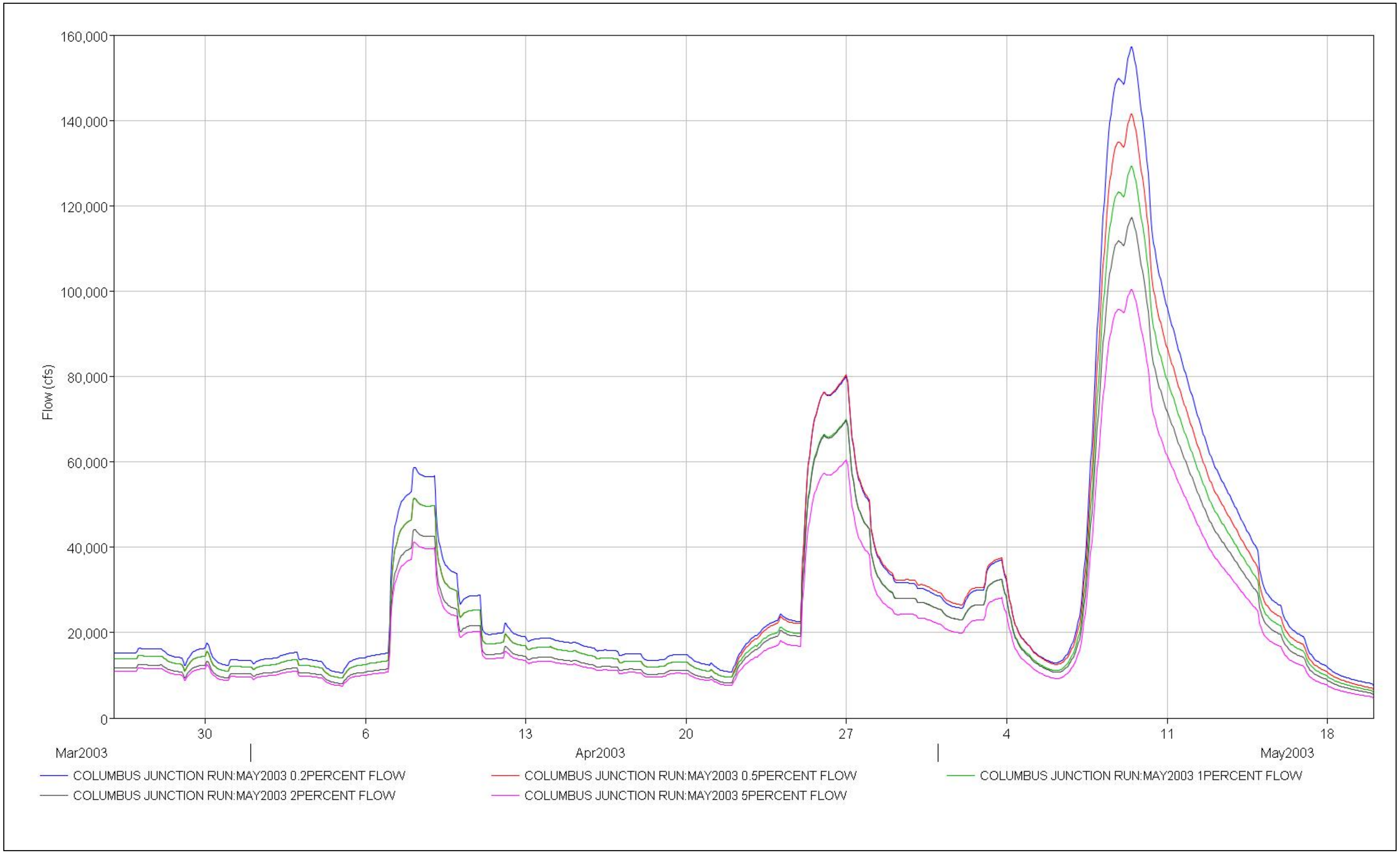

Figure J.11 HEC-HMS Hourly Unimpaired Hypothetical Hydrographs for the May 2003 Event

Table J-04. Computed Unimpaired Hourly Hypothetical Flows and HEC-HMS Unimpaired Hourly Hypothetical Flows for the March 1990 Event

Percent Chance Exceedance	From Computed Hourly Unimpaired Flow at Columbus					From HEC-HMS Model using March 1990 Flood at Columbus					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	100,571	95,453	83,633	69,962	25,506	100,536	94,886	88,852	75,045	24,699	0.03	0.59	6.24	7.27	3.16
2	117,185	111,221	98,050	82,044	29,071	117,151	110,568	106,527	90,575	29,214	0.03	0.59	8.65	10.40	0.49
1	129,461	122,872	108,840	91,143	31,656	129,455	122,181	117,715	100,088	32,282	0.00	0.56	8.15	9.81	1.98
0.5	141,594	134,388	119,616	100,280	34,176	141,549	133,595	128,712	109,438	35,298	0.03	0.59	7.60	9.13	3.28
0.2	157,511	149,495	133,923	112,487	37,434	157,534	148,682	143,247	121,796	39,284	0.01	0.54	6.96	8.28	4.94

Table J-05. Computed Unimpaired Hourly Hypothetical Flows and HEC-HMS Unimpaired Hourly Hypothetical Flows for the May 2003 Event

Percent Chance Exceedance	From Computed Hourly Unimpaired Flow at Columbus					From HEC-HMS Model using May 2003 Flood at Columbus					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	100,571	95,453	83,633	69,962	25,506	100,571	97,251	84,377	71,076	25,531	0.00	1.88	0.89	1.59	0.10
2	117,185	111,221	98,050	82,044	29,071	117,185	113,314	98,314	82,816	29,025	0.00	1.88	0.27	0.94	0.16
1	129,461	122,872	108,840	91,143	31,656	129,310	125,015	108,457	91,363	31,571	0.12	1.74	0.35	0.24	0..27
0.5	141,594	134,388	119,616	100,280	34,176	141,556	136,868	118,745	100,028	34,271	0.03	1.85	0.73	0.25	0.28
0.2	157,511	149,495	133,923	112,487	37,434	157,473	152,229	132,061	112,249	37,227	0.02	1.83	1.39	0.21	0.55

Appendix J-A

Development of Instantaneous vs. Peak Flow Relationships

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

Appendix J-A

Instantaneous Peak Flow
vs.
Daily Average Flow Relationships

Instantaneous peak flow vs. daily average flow relationships were developed for stream gages on the Chattahoochee River above Columbus as well as tributaries upstream of Uchee Creek. These relationships were developed by comparing the annual peak discharge and average daily discharge data obtained from the USGS gages shown in Table J-A-01. An effort was made to remove the influence of reservoirs when developing these relationships; therefore, only stream flow records prior to 1957 were included in the analysis of Chattahoochee stream gages downstream of Buford Dam. This could include some influence from the Morgan Falls Dam because it was in place prior to 1957, however, the influence should be minor. Morgan Falls Dam was raised to its current height in 1957, corresponding to the completion of Buford Dam.

The Chattahoochee River, major reservoir locations, and stream gage locations used in this analysis are shown in Figure J-A.01. Table J-A-02 contains a description of the major reservoirs upstream of Columbus. The instantaneous peak flow vs. daily average flow relationships are shown in Figure J-A.02 through Figure J-A.14, and the data used to develop these relationships are shown in Table J-A-03 through Table J-A-14.

One interesting point to note is that, as shown in Figure J-A.02, the slope of the line for the instantaneous peak flow vs. daily average flow relationships for Chattahoochee stream gages becomes flatter (closer to 1:1) as the drainage area increases. In addition, there is little difference among the instantaneous peak flow vs. daily average flow relationship at the Norcross, Atlanta, and West Point gages. Therefore, the instantaneous peak flow vs. daily average flow relationship at the West Point gage should be applicable for computing the instantaneous peak flows (unimpaired) at Columbus (drainage area 4670 square miles) given daily average flow (unimpaired).

Another point of interest is that, as shown in Figure J-A.07, the instantaneous peak flow vs. daily average flow relationship at the West Point stream gage shows little difference in the instantaneous peak and corresponding daily average flow. This is a result of the large drainage area upstream of the West Point gage (3550 square miles). Flashy hydrographs from upstream areas are attenuated by natural storage in the channel and overbank areas as they travel downstream.

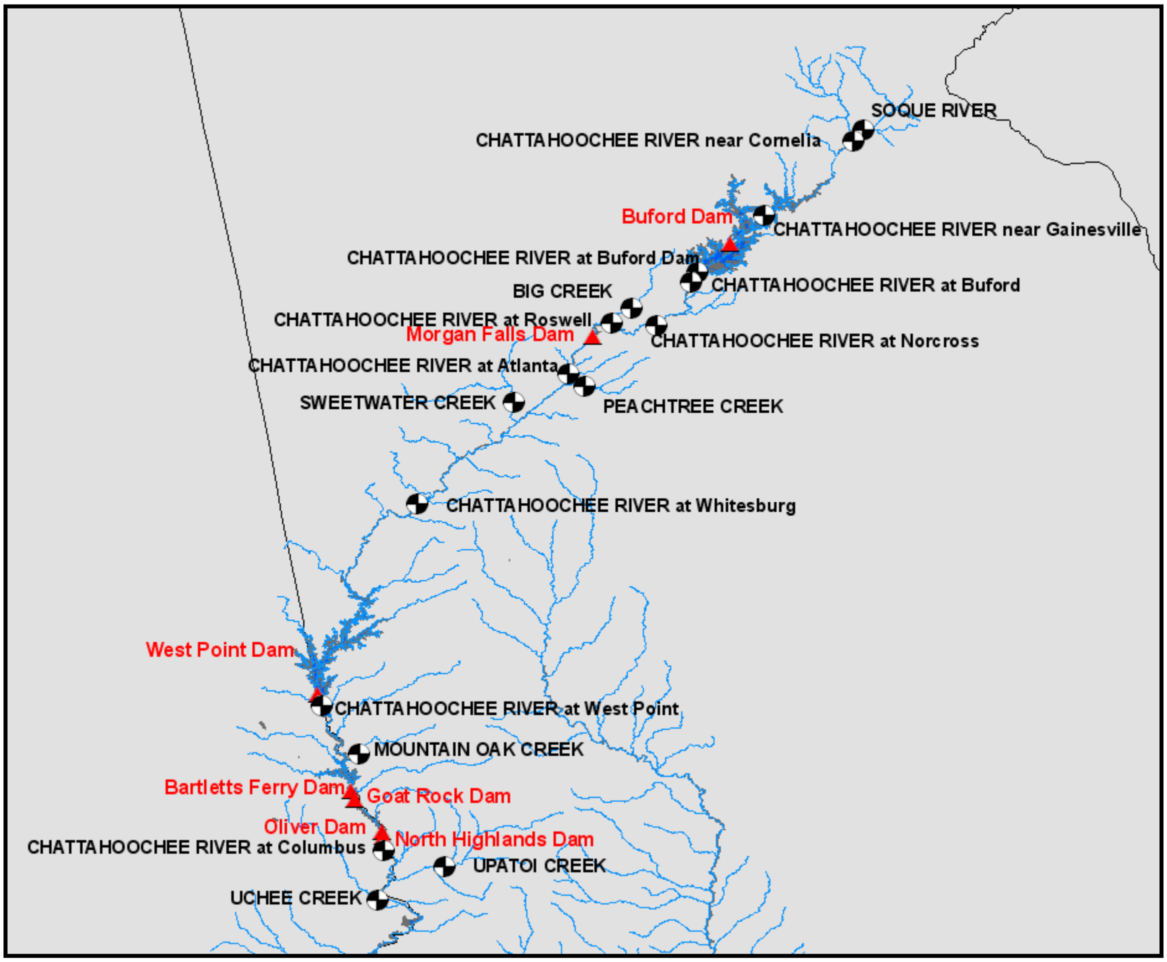

Figure J-A.01 Chattahoochee River - Columbus Analysis

Table J-A-01. USGS Stream Gages

Gage Name	USGS ID	Latitude	Longitude	Drainage Area (sq miles)
SOQUE RIVER	USGS02331500	34.5725	-83.5911	156
CHATTAHOOCHEE RIVER at Buford Dam	USGS02334430	34.1547	-84.0778	1040
CHATTAHOOCHEE RIVER at Buford	USGS02334500	34.1272	-84.0983	1060
BIG CREEK	USGS02335700	34.0506	-84.2694	72
CHATTAHOOCHEE RIVER at Norcross	USGS02335000	33.9975	-84.1997	1170
CHATTAHOOCHEE RIVER at Roswell	USGS02335500	34.0056	-84.3297	1230
CHATTAHOOCHEE RIVER at Atlanta	USGS02336000	33.8592	-84.4564	1450
PEACHTREE CREEK	USGS02336300	33.8197	-84.4103	87
SWEETWATER CREEK	USGS02337000	33.7742	-84.6144	246
CHATTAHOOCHEE RIVER at Whitesburg	USGS02338000	33.4764	-84.8997	2430
CHATTAHOOCHEE RIVER at West Point	USGS02339500	32.8853	-85.1786	3550
MOUNTAIN OAK CREEK	USGS02340500	32.7414	-85.0683	62
CHATTAHOOCHEE RIVER at Columbus	USGS02341500	32.4608	-84.9958	4670
UPATOI CREEK	USGS02341800	32.4142	-84.8197	342
UCHEE CREEK	USGS02342500	32.3153	-85.0164	322
CHATTAHOOCHEE RIVER near Cornelia	USGS02331600	34.5408	-83.6205	315
CHATTAHOOCHEE RIVER near Gainesville	USGS02333000	34.3219	-83.8817	559

Table J-A-02. Reservoirs

Reservoir Name	Description	Alias	Completion Date	Latitude	Longitude	Drainage Area (sq miles)
Buford	USACE	Lake Lanier	1957	34.2389	-83.9822	1040
Morgan Falls	Dam Height - 56ft	Bull Sluice Lake	1904 Raised 1957	33.9682	-84.3833	1370
West Point	USACE		1975	32.9185	-85.1880	3400
Bartlett's Ferry	Dam Height over 100ft	Lake Harding	1920s	32.6330	-85.0910	
Goat Rock	Reservoir Area - 940acre Dam Height – 60ft		1912	32.6090	-85.0790	
Oliver	Dam Height - 70ft		1959	32.5160	-84.9990	
North Highlands	Dam Height - 33ft		1899	32.4995	-84.9960	

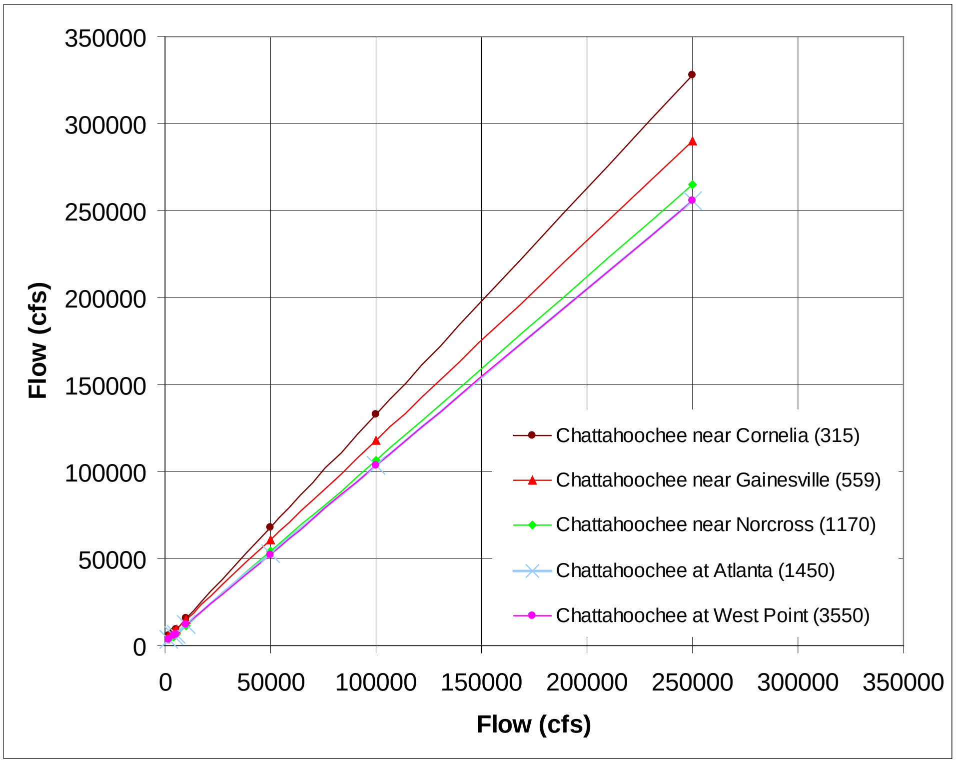

Figure J-A.02 Instantaneous Peak Flow vs. Daily Average Flow Relationship for Stream Gages on the Chattahoochee River

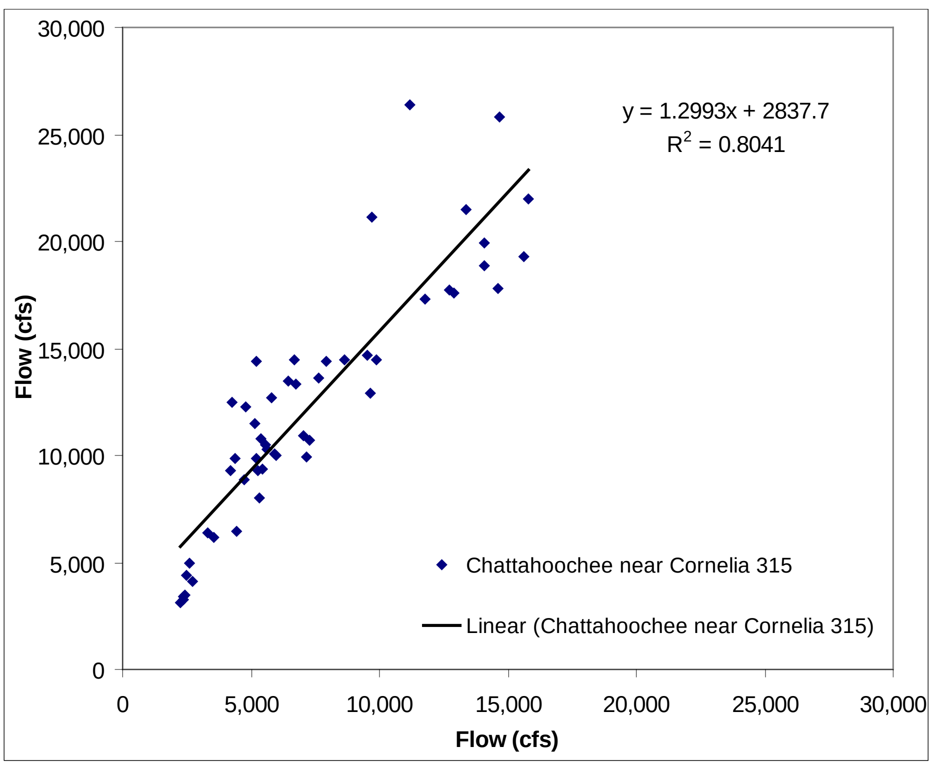

Figure J-A.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Cornelia Gage

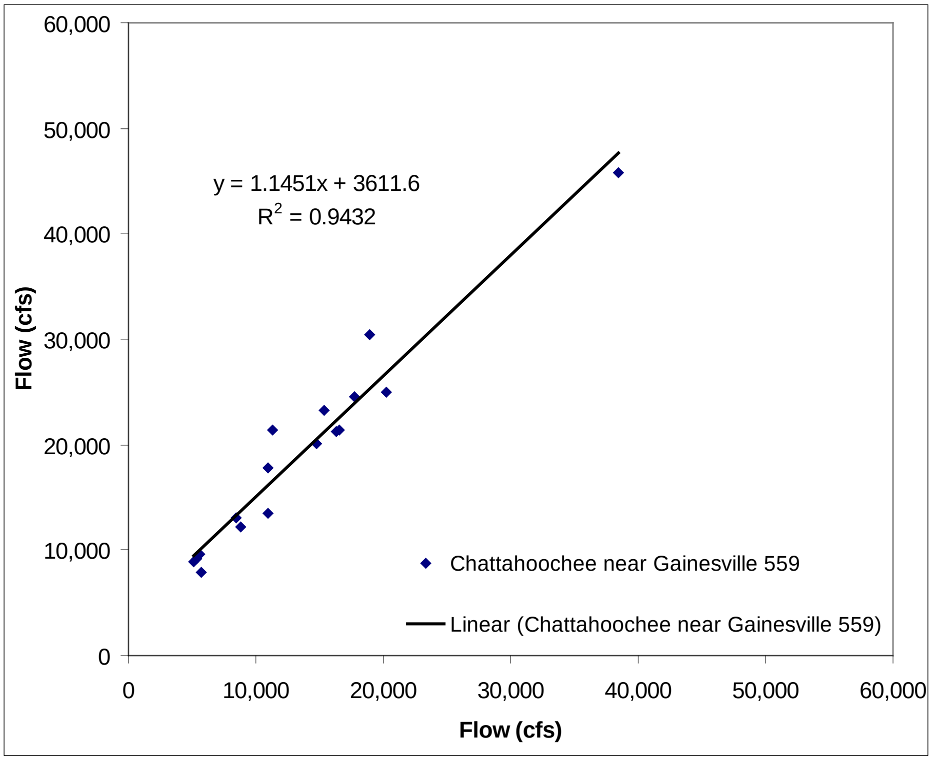

Figure J-A.04 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Gainesville Gage

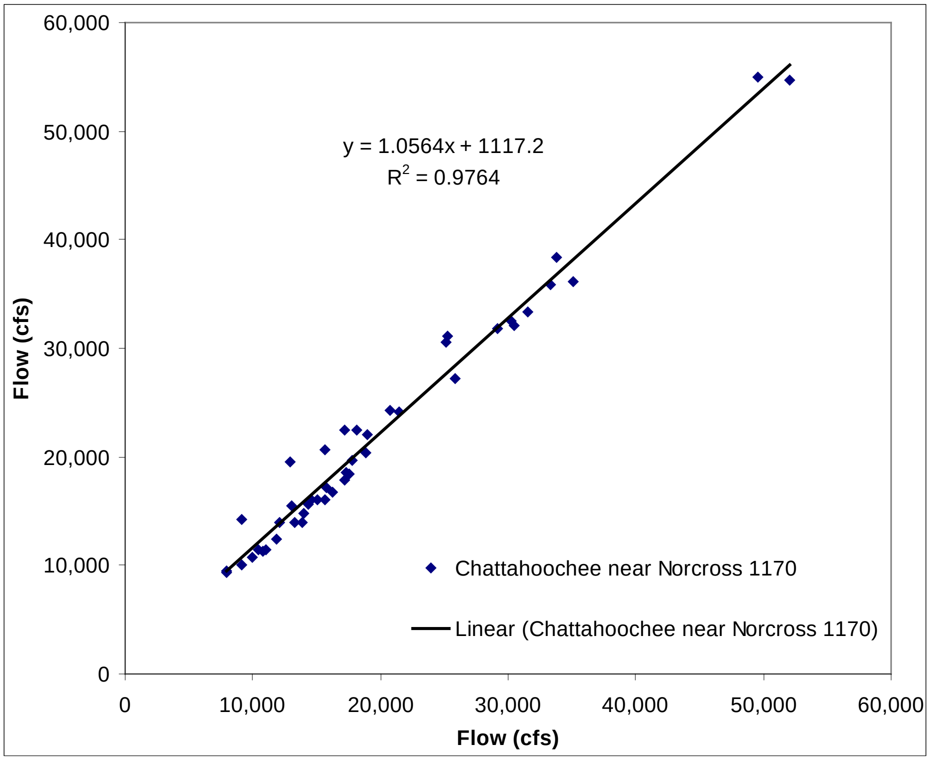

Figure J-A.05 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Norcross Gage

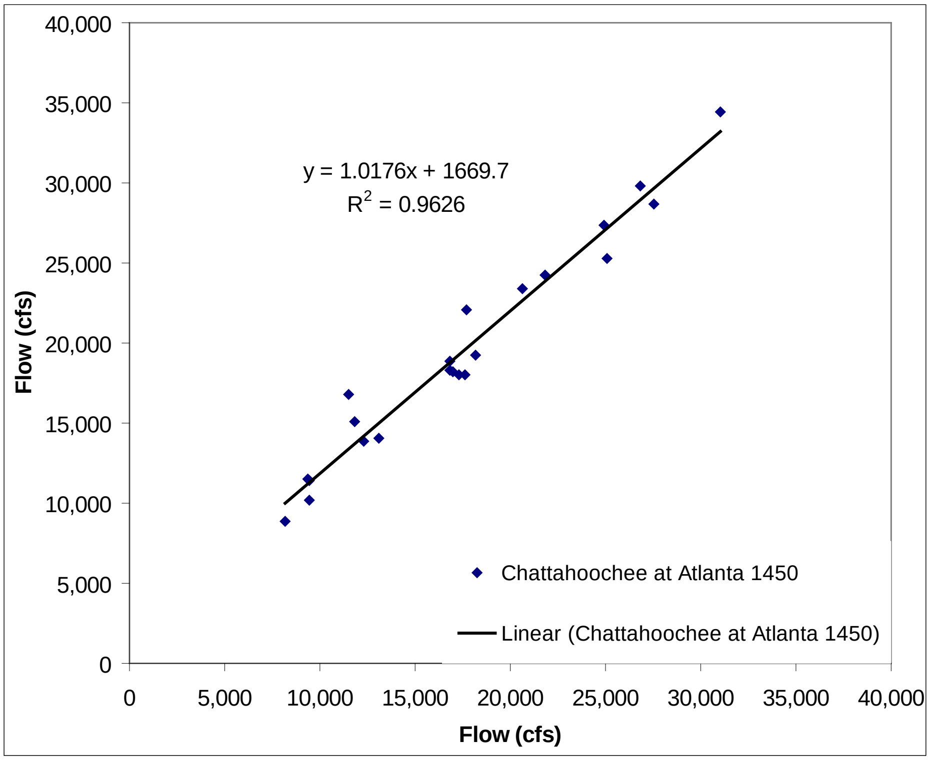

Figure J-A.06 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Atlanta Gage

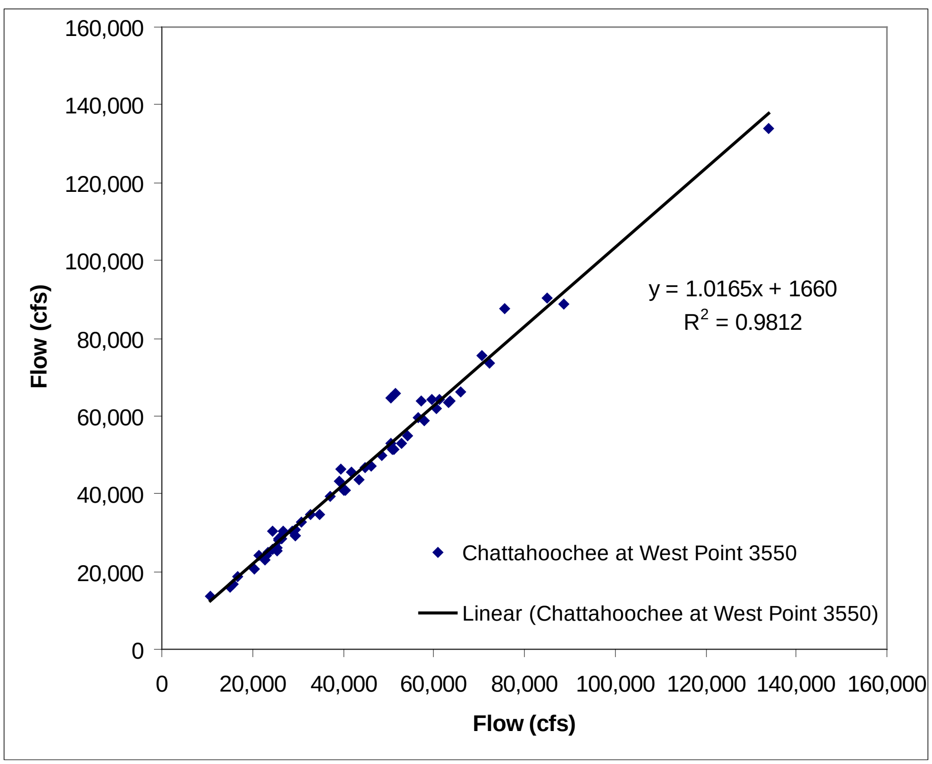

Figure J-A.07 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

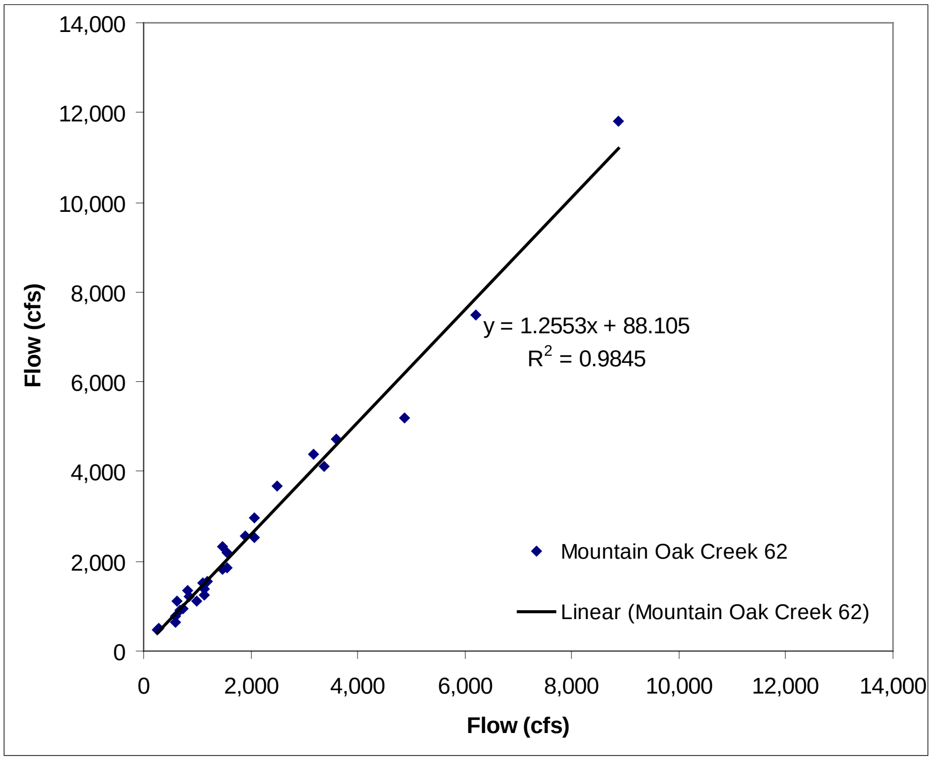

Figure J-A.08 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Mountain Oak Creek Gage

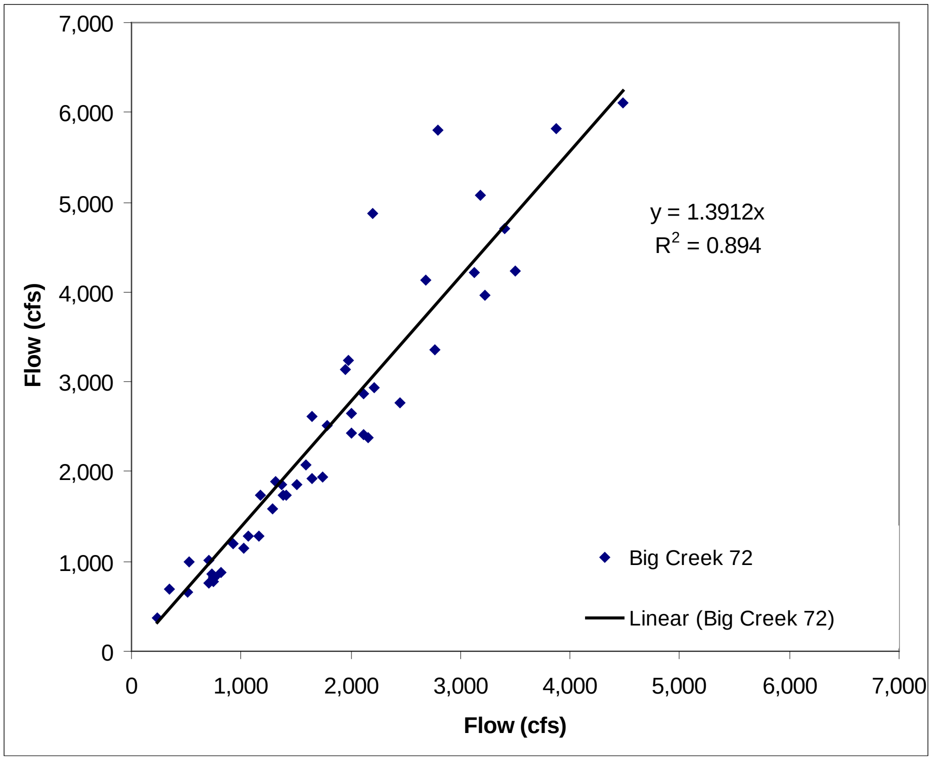

Figure J-A.09 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Big Creek Gage

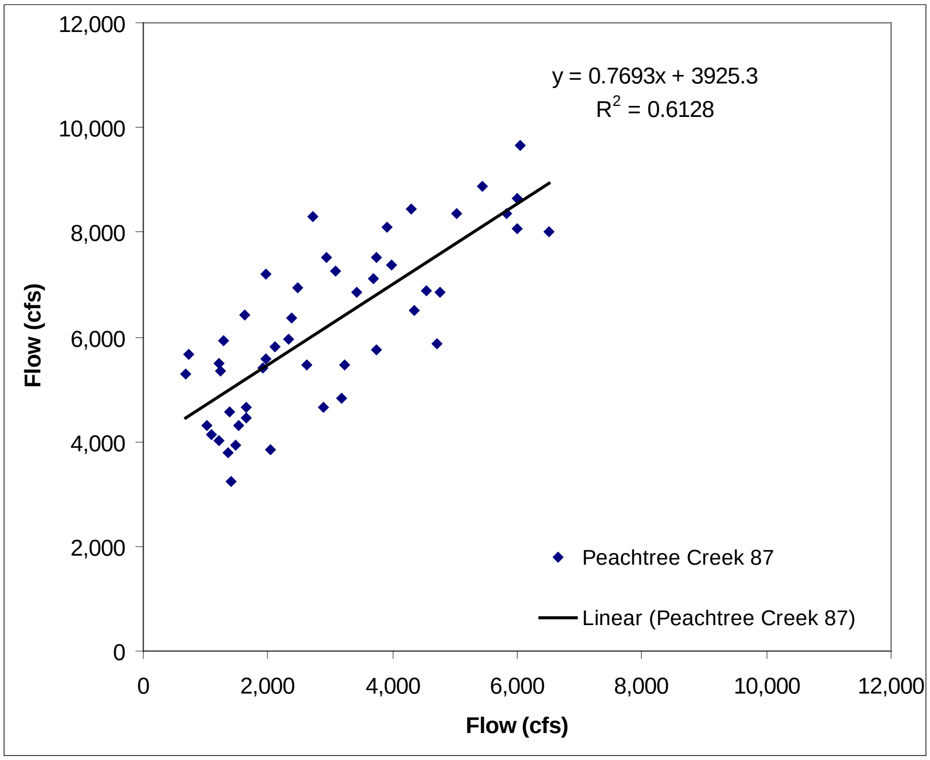

Figure J-A.10 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Peachtree Gage

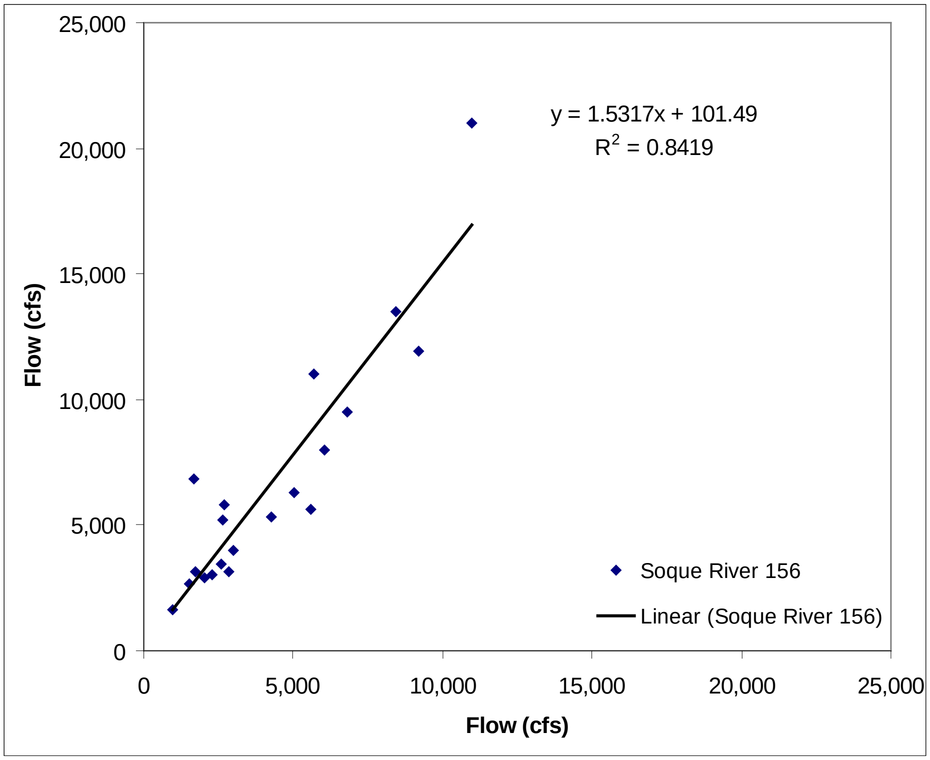

Figure J-A.11 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Soque River Gage

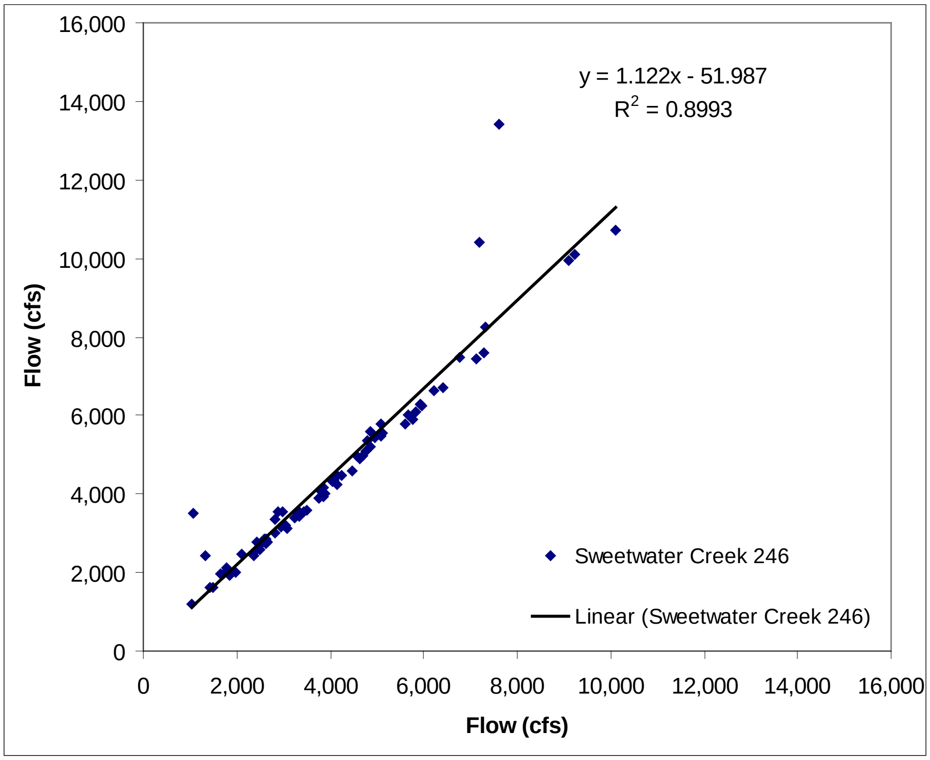

Figure J-A.12 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Sweetwater Creek Gage

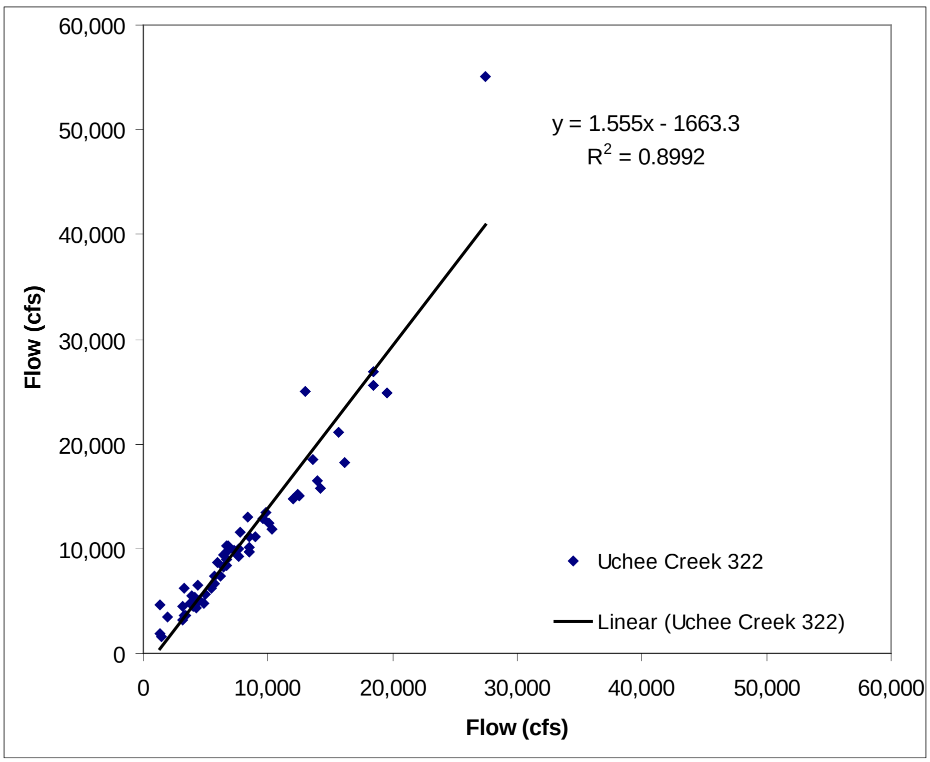

Figure J-A.13 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Uchee Creek Gage

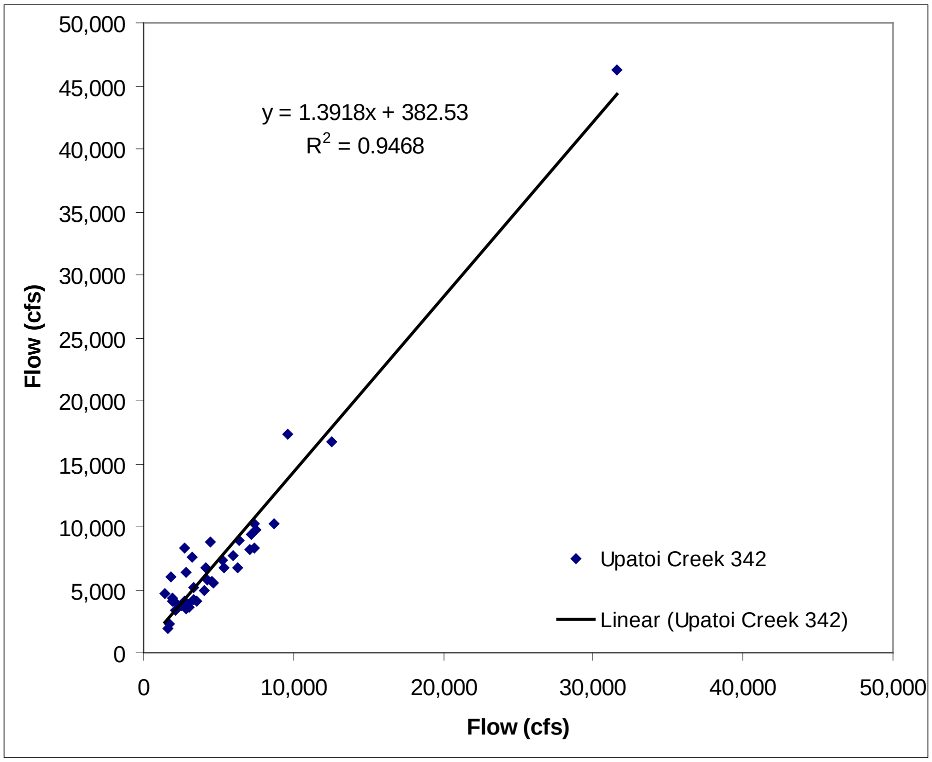

Figure J-A.14 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Upatoi Creek Gage

Table J-A-03. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Cornelia Gage (315)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
19 Nov 57, 24:00	5,350	8,000
31 May 59, 24:00	5,200	9,840
05 Feb 60, 24:00	3,550	6,200
25 Feb 61, 24:00	9,640	12,900
12 Dec 61, 24:00	14,600	17,800
12 Mar 63, 24:00	11,200	26,400
25 Jan 64, 24:00	8,650	14,500
04 Oct 64, 24:00	5,150	11,500
13 Feb 66, 24:00	12,700	17,700
23 Aug 67, 24:00	15,800	22,000
12 Mar 68, 24:00	7,260	10,700
03 Feb 69, 24:00	5,650	10,300
02 Nov 69, 24:00	2,380	3,380
31 Jul 71, 24:00	3,340	6,400
14 May 72, 24:00	5,570	10,500
28 May 73, 24:00	14,700	25,800
31 Dec 73, 24:00	4,400	9,840
14 Mar 75, 24:00	7,030	10,900
29 May 76, 24:00	9,690	21,100
30 Mar 77, 24:00	15,600	19,300
25 Jan 78, 24:00	5,210	14,400
13 Apr 79, 24:00	12,900	17,600
17 Mar 80, 24:00	6,690	14,500
27 May 81, 24:00	2,460	4,400
03 Feb 82, 24:00	9,870	14,500
02 Feb 83, 24:00	6,760	13,300
04 Dec 83, 24:00	5,900	10,100
02 Feb 85, 24:00	2,700	4,120
30 Nov 85, 24:00	2,350	3,240
26 Nov 86, 24:00	5,790	12,700
20 Jan 88, 24:00	5,250	9,270
20 Jun 89, 24:00	5,440	9,360
17 Mar 90, 24:00	14,100	18,900
26 Aug 91, 24:00	5,980	10,000
28 Aug 92, 24:00	4,730	8,840
17 Dec 92, 24:00	7,180	9,920
17 Aug 94, 24:00	11,800	17,300
16 Feb 95, 24:00	4,230	9,270
27 Jan 96, 24:00	13,400	21,500
01 Dec 96, 13:45	9,520	14,700
26 Oct 97, 12:15	7,940	14,400
01 Feb 99, 14:00	4,430	6,470
10 Oct 99, 19:45	4,270	12,500
19 Jan 01, 18:45	2,620	4,990
25 Jan 02, 04:15	2,260	3,120
02 Jul 03, 03:30	7,660	13,600
17 Sep 04, 05:00	14,100	19,900
07 Aug 05, 17:45	4,780	12,300
18 Jan 06, 02:30	2,410	3,490
02 Mar 07, 01:15	5,380	10,800
26 Aug 08, 20:45	6,430	13,500

Table J-A-04. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Gainesville Gage (559)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
18 Aug 39, 24:00	10,900	13,500
14 Aug 40, 24:00	18,900	30,500
15 Jul 41, 24:00	5,410	9,150
17 Feb 42, 24:00	15,300	23,300
30 Dec 42, 24:00	8,460	13,000
20 Mar 44, 24:00	16,300	21,200
17 Sep 45, 24:00	5,100	8,910
07 Jan 46, 24:00	38,500	45,800
20 Jan 47, 24:00	14,800	20,100
04 Aug 48, 24:00	10,900	17,800
17 Jun 49, 24:00	17,700	24,600
14 Mar 50, 24:00	5,580	9,600
20 Oct 50, 24:00	5,760	7,850
11 Mar 52, 24:00	20,200	25,000
23 Jul 53, 24:00	8,760	12,200
17 Jan 54, 24:00	11,300	21,400
07 Feb 55, 24:00	16,600	21,400

Table J-A-05. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Norcross Gage (1170)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
24 Mar 03, 24:00	30,200	32,500
09 Aug 04, 24:00	9,120	14,300
13 Jan 05, 24:00	15,600	16,100
04 Jan 06, 24:00	20,800	24,300
03 Oct 06, 24:00	13,900	13,900
26 Apr 08, 24:00	18,900	20,400
14 Mar 09, 24:00	19,000	22,000
09 May 10, 24:00	11,900	12,400
06 Apr 11, 24:00	12,100	14,000
16 Mar 12, 24:00	25,100	30,500
15 Mar 13, 24:00	15,100	16,000
15 Apr 14, 24:00	10,800	11,300
05 Dec 14, 24:00	17,500	18,400
30 Dec 15, 24:00	35,100	36,200
25 Mar 17, 24:00	21,500	24,200
29 Jan 18, 24:00	10,000	10,800
23 Dec 18, 24:00	33,300	35,900
10 Dec 19, 24:00	52,000	54,700
10 Feb 21, 24:00	31,600	33,300
11 Mar 22, 24:00	13,300	14,000
18 Dec 22, 24:00	17,300	18,600
19 Apr 24, 24:00	10,400	11,400
19 Jan 25, 24:00	16,200	16,800
19 Jan 26, 24:00	17,800	19,700
14 Feb 27, 24:00	11,000	11,400
17 Aug 28, 24:00	14,400	15,600
27 Sep 29, 24:00	25,300	31,100
08 Mar 30, 24:00	14,600	16,000
17 Nov 30, 24:00	9,130	10,000
16 Dec 31, 24:00	12,900	19,500
29 Dec 32, 24:00	30,500	32,100
05 Mar 34, 24:00	29,200	31,800
07 Oct 34, 24:00	15,800	17,200
07 Apr 36, 24:00	33,800	38,400
04 Jan 37, 24:00	25,800	27,200
23 Jul 38, 24:00	17,200	17,800
19 Aug 39, 24:00	14,000	14,800
15 Aug 40, 24:00	17,200	22,500
06 Jul 41, 24:00	7,950	9,340
18 Feb 42, 24:00	15,700	20,600
31 Dec 42, 24:00	13,000	15,500
30 Mar 44, 24:00	18,200	22,500
26 Apr 45, 24:00	7,950	9,460
08 Jan 46, 24:00	49,600	55,000

Table J-A-06. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Atlanta Gage (1450)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
28 Sep 29, 24:00	27,500	28,700
09 Mar 30, 24:00	11,500	16,800
17 Nov 30, 24:00	8,200	8,900
16 Dec 31, 24:00	16,800	18,900
04 Jan 37, 24:00	25,100	25,300
24 Jul 38, 24:00	16,800	18,300
19 Aug 39, 24:00	13,100	14,100
15 Aug 40, 24:00	21,800	24,200
07 Jul 41, 24:00	9,380	11,500
19 Feb 42, 24:00	17,700	22,100
31 Dec 42, 24:00	18,200	19,200
31 Mar 44, 24:00	20,600	23,400
23 Feb 45, 24:00	9,440	10,200
22 Jan 47, 24:00	26,800	29,800
06 Aug 48, 24:00	17,000	18,200
15 Mar 50, 24:00	12,300	13,900
21 Oct 50, 24:00	9,480	11,400
13 Mar 52, 24:00	31,000	34,400
11 Jan 53, 24:00	17,300	18,000
18 Jan 54, 24:00	24,900	27,400
09 Feb 55, 24:00	17,600	18,000
16 Mar 56, 24:00	11,800	15,100

Table J-A-07. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage (3550)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
28 Feb 99, 24:00	43,600	43,600
14 Feb 00, 24:00	63,300	63,300
23 May 01, 24:00	52,800	52,800
30 Dec 01, 24:00	88,600	88,600
09 Feb 03, 24:00	66,100	66,100
09 Aug 04, 24:00	29,300	29,300
13 Jan 05, 24:00	29,300	29,300
20 Mar 06, 24:00	50,800	51,800
03 Mar 07, 24:00	28,800	30,500
26 Apr 08, 24:00	40,500	40,800
13 Mar 09, 24:00	51,200	51,500
25 May 10, 24:00	22,800	23,100
10 Apr 11, 24:00	20,400	20,700
16 Mar 12, 24:00	72,200	73,400
15 Mar 13, 24:00	45,000	46,900
17 Apr 14, 24:00	16,800	18,500
06 Dec 14, 24:00	23,500	25,000
10 Jul 16, 24:00	50,400	64,500
28 Mar 17, 24:00	51,000	51,400
12 Jan 18, 24:00	34,800	34,800
23 Dec 18, 24:00	63,700	63,700
10 Dec 19, 24:00	134,000	134,000
10 Feb 21, 24:00	50,600	53,000
11 Mar 22, 24:00	54,200	54,800
14 Feb 23, 24:00	37,100	39,400
19 Apr 24, 24:00	25,400	25,400
19 Jan 25, 24:00	85,000	90,300
01 Apr 26, 24:00	26,400	28,500
14 Feb 27, 24:00	21,300	24,100
23 Apr 28, 24:00	26,700	30,500
15 Mar 29, 24:00	75,500	87,600
16 Nov 29, 24:00	25,800	28,200
17 Nov 30, 24:00	29,500	30,900
22 Feb 32, 24:00	26,400	29,200
30 Dec 32, 24:00	58,000	58,600
05 Mar 34, 24:00	32,900	34,700
12 Oct 34, 24:00	24,500	30,200
08 Apr 36, 24:00	70,600	75,400
06 Jan 37, 24:00	48,700	49,900
09 Apr 38, 24:00	57,300	63,900
01 Mar 39, 24:00	41,800	45,500
10 Jul 40, 24:00	25,700	28,600
17 Jul 41, 24:00	10,700	13,800
22 Mar 42, 24:00	61,200	64,200
22 Mar 43, 24:00	59,700	64,200
27 Apr 44, 24:00	39,600	46,200
25 Apr 45, 24:00	51,700	65,700
12 Jan 46, 24:00	56,600	59,700
21 Jan 47, 24:00	46,300	47,200
12 Jul 48, 24:00	30,700	32,800
29 Nov 48, 24:00	60,700	61,900
16 Mar 50, 24:00	15,200	16,000
23 Apr 51, 24:00	15,800	16,800
05 Mar 52, 24:00	39,200	43,200
10 Jan 53, 24:00	25,500	26,100
20 Jan 54, 24:00	24,600	25,800
08 Feb 55, 24:00	23,100	24,000
17 Mar 56, 24:00	40,000	40,900

Table J-A-08. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Mountain Oak Creek Gage (62)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
27 Apr 44, 24:00	3,180	4,380
13 May 45, 24:00	1,470	1,810
07 Jan 46, 24:00	3,370	4,120
02 Apr 47, 24:00	1,550	2,180
11 Jul 48, 24:00	8,860	11,800
27 Nov 48, 24:00	6,210	7,490
28 Mar 50, 24:00	608	780
23 Apr 51, 24:00	262	462
25 Mar 52, 24:00	857	1,220
01 May 53, 24:00	670	899
05 Dec 53, 24:00	1,460	2,340
14 Apr 55, 24:00	605	630
16 Mar 56, 24:00	738	955
05 Apr 57, 24:00	1,890	2,580
19 Nov 57, 24:00	980	1,100
04 Feb 59, 24:00	285	515
04 Apr 60, 24:00	1,570	1,840
25 Feb 61, 24:00	4,870	5,200
13 Apr 62, 24:00	1,110	1,520
21 Jan 63, 24:00	1,120	1,260
08 Apr 64, 24:00	2,080	2,960
05 Oct 64, 24:00	1,130	1,380
13 Feb 66, 24:00	2,500	3,690
04 Sep 67, 24:00	632	1,130
12 Mar 68, 24:00	1,180	1,560
19 Apr 69, 24:00	833	1,360
22 Mar 70, 24:00	2,080	2,530
03 Mar 71, 24:00	3,610	4,710

Table J-A-09. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Big Creek Gage (72)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
21 Feb 61, 24:00	2,800	5,800
13 Dec 61, 24:00	3,410	4,700
30 Apr 63, 24:00	2,110	2,860
26 Mar 64, 24:00	2,680	4,140
23 Jan 65, 24:00	339	684
05 Mar 66, 24:00	1,980	3,240
25 Aug 67, 24:00	1,070	1,280
11 Jan 68, 24:00	1,280	1,580
23 Aug 69, 24:00	1,380	1,740
21 Mar 70, 24:00	810	879
04 Mar 71, 24:00	758	820
11 Jan 72, 24:00	2,000	2,430
17 Mar 73, 24:00	1,180	1,740
01 Jan 74, 24:00	1,780	2,510
14 Mar 75, 24:00	1,740	1,940
31 Mar 76, 24:00	1,650	2,620
30 Mar 77, 24:00	3,180	5,080
06 Nov 77, 24:00	1,310	1,890
14 Apr 79, 24:00	3,120	4,220
09 Mar 80, 24:00	2,010	2,640
19 Feb 81, 24:00	747	823
03 Feb 82, 24:00	4,480	6,100
09 Apr 83, 24:00	1,020	1,150
06 Dec 83, 24:00	2,200	4,880
02 Feb 85, 24:00	753	817
04 Sep 86, 24:00	236	379
01 Mar 87, 24:00	2,110	2,410
13 Sep 88, 24:00	1,590	2,080
23 Jun 89, 24:00	512	652
17 Mar 90, 24:00	3,870	5,820
02 Sep 91, 24:00	706	1,010
26 Feb 92, 24:00	1,370	1,860
13 Jan 93, 24:00	3,220	3,970
29 Mar 94, 24:00	730	856
17 Feb 95, 24:00	2,160	2,380
28 Jan 96, 24:00	1,950	3,140
01 Mar 97, 01:30	2,450	2,760
09 Mar 98, 05:15	2,770	3,360
01 Feb 99, 16:45	712	754
21 Sep 00, 17:30	522	993
20 Jan 01, 21:00	1,160	1,280
31 Mar 02, 23:30	1,510	1,860
07 Mar 03, 02:30	2,220	2,930
17 Sep 04, 18:15	3,500	4,230
16 Jul 05, 04:00	1,650	1,920
22 Mar 06, 05:00	926	1,200
17 Nov 06, 01:00	1,410	1,740
05 Mar 08, 02:15	742	775

Table J-A-10. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Peachtree Creek Gage (87)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
30 May 59, 24:00	1,020	4,300
03 Apr 60, 24:00	1,410	3,230
25 Feb 61, 24:00	4,720	5,860
22 Feb 62, 24:00	2,900	4,650
30 Apr 63, 24:00	4,540	6,880
06 Apr 64, 24:00	3,740	5,760
23 Jan 65, 24:00	1,350	3,800
13 Feb 66, 24:00	3,190	4,830
29 Jul 67, 24:00	1,250	5,340
12 Mar 68, 24:00	2,050	3,840
18 Apr 69, 24:00	4,750	6,840
19 Mar 70, 24:00	2,480	6,950
30 Jul 71, 24:00	1,220	5,500
10 Jan 72, 24:00	3,230	5,470
01 Feb 73, 24:00	1,290	5,930
31 Dec 73, 24:00	2,330	5,960
13 Mar 75, 24:00	5,830	8,350
16 Mar 76, 24:00	6,000	8,660
21 Mar 77, 24:00	1,220	4,030
25 Jan 78, 24:00	2,620	5,460
13 Apr 79, 24:00	5,990	8,070
23 May 80, 24:00	2,370	6,360
11 Feb 81, 24:00	1,530	4,300
03 Feb 82, 24:00	4,340	6,520
08 Apr 83, 24:00	3,690	7,120
02 May 84, 24:00	1,630	6,420
17 Aug 85, 24:00	2,120	5,810
01 Oct 85, 24:00	1,490	3,920
18 Jan 87, 24:00	3,900	8,110
11 Apr 88, 24:00	690	5,300
30 Sep 89, 24:00	2,710	8,310
17 Mar 90, 24:00	6,060	9,650
19 May 91, 24:00	2,950	7,520
05 Sep 92, 24:00	4,300	8,450
25 Nov 92, 24:00	3,980	7,380
18 Sep 94, 24:00	3,740	7,530
08 Mar 95, 24:00	1,640	4,440
04 Oct 95, 24:00	6,500	8,010
23 Jul 97, 10:00	3,430	6,860
08 Mar 98, 11:30	5,430	8,880
06 Jul 99, 18:00	721	5,670
21 Sep 00, 13:45	1,960	5,580
15 Mar 01, 06:30	1,910	5,410
04 May 02, 10:45	3,090	7,270
16 May 03, 04:30	1,960	7,190
11 Jul 05, 04:45	5,040	8,370
31 Aug 06, 02:45	1,640	4,660
15 Nov 06, 19:15	1,390	4,570
28 Dec 07, 09:45	1,100	4,140

Table J-A-11. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Soque Creek Gage (156)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
30 Jun 05, 24:00	5,680	11,000
18 Aug 06, 24:00	6,820	9,500
03 Oct 06, 24:00	2,850	3,150
25 Apr 08, 24:00	5,610	5,610
26 Sep 29, 24:00	6,030	8,020
07 Mar 30, 24:00	2,040	2,880
16 Nov 30, 24:00	982	1,630
21 Jul 38, 24:00	4,280	5,310
13 Aug 40, 24:00	9,190	11,900
07 Jul 41, 24:00	2,600	3,450
16 Feb 42, 24:00	1,670	6,820
19 Apr 43, 24:00	3,000	4,010
19 Mar 44, 24:00	2,710	5,820
16 Sep 45, 24:00	1,510	2,650
07 Jan 46, 24:00	8,420	13,500
20 Jan 47, 24:00	5,040	6,310
12 Jul 48, 24:00	2,660	5,190
16 Jun 49, 24:00	11,000	21,000
08 Jun 50, 24:00	1,720	3,150
20 Oct 50, 24:00	2,310	3,040

Table J-A-12. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Sweetwater Creek Gage (246)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
09 Aug 04, 24:00	5,760	5,910
12 Jul 05, 24:00	5,960	6,260
01 May 37, 24:00	4,800	5,360
09 Apr 38, 24:00	6,230	6,640
01 Mar 39, 24:00	2,500	2,580
10 Jul 40, 24:00	3,440	3,540
17 Jul 41, 24:00	1,490	1,630
22 Mar 42, 24:00	4,240	4,460
22 Mar 43, 24:00	4,860	5,190
30 Mar 44, 24:00	3,230	3,390
25 Apr 45, 24:00	1,770	2,130
08 Jan 46, 24:00	5,680	6,000
21 Jan 47, 24:00	5,820	6,110
10 Feb 48, 24:00	3,350	3,440
29 Nov 48, 24:00	7,180	10,400
09 Sep 50, 24:00	1,990	2,020
23 Apr 51, 24:00	1,730	1,950
22 Dec 51, 24:00	4,690	4,970
10 Jan 53, 24:00	3,090	3,130
17 Jan 54, 24:00	3,310	3,490
08 Feb 55, 24:00	2,480	2,680
16 Mar 56, 24:00	2,880	3,540
06 Apr 57, 24:00	4,640	4,910
07 Feb 58, 24:00	1,840	1,910
02 Jun 59, 24:00	3,750	3,900
01 Feb 60, 24:00	2,620	2,720
26 Feb 61, 24:00	9,240	10,100
19 Dec 61, 24:00	4,560	4,980
01 May 63, 24:00	4,070	4,350
08 Apr 64, 24:00	5,940	6,270
28 Dec 64, 24:00	3,860	4,160
05 Mar 66, 24:00	4,940	5,420
26 Aug 67, 24:00	4,040	4,330
11 Jan 68, 24:00	2,380	2,490
18 Apr 69, 24:00	2,440	2,760
21 Mar 70, 24:00	5,110	5,540
04 Mar 71, 24:00	3,500	3,580
12 Jan 72, 24:00	7,130	7,430
18 Mar 73, 24:00	3,840	3,940
02 Jan 74, 24:00	4,140	4,250
15 Mar 75, 24:00	7,330	8,240
17 Mar 76, 24:00	5,920	6,280
31 Mar 77, 24:00	7,290	7,590
07 Nov 77, 24:00	5,080	5,480
14 Apr 79, 24:00	6,760	7,490
09 Mar 80, 24:00	3,050	3,210
28 May 81, 24:00	3,750	3,900
04 Feb 82, 24:00	10,100	10,700
09 Apr 83, 24:00	3,320	3,530
07 Dec 83, 24:00	4,150	4,490
02 May 85, 24:00	1,340	2,420
13 Dec 85, 24:00	1,030	1,200
20 Jan 87, 24:00	3,900	4,020
20 Jan 88, 24:00	1,660	1,980
07 Jul 89, 24:00	2,960	3,150
18 Mar 90, 24:00	9,100	9,950
06 May 91, 24:00	2,970	3,550
21 Aug 92, 24:00	1,060	3,510
18 Dec 92, 24:00	4,470	4,590
02 Mar 94, 24:00	2,120	2,460
17 Feb 95, 24:00	4,870	5,580
08 Mar 96, 24:00	5,590	5,790
01 Mar 97, 23:00	4,770	5,090
09 Mar 98, 19:00	6,400	6,720
01 Jul 99, 18:00	2,820	3,340
04 Apr 00, 16:30	2,350	2,430
21 Mar 01, 09:30	2,670	2,760
31 Mar 02, 19:45	2,590	2,840
07 May 03, 24:00	5,090	5,780
18 Sep 04, 01:00	3,800	4,080
11 Jul 05, 24:00	7,600	13,400
24 Jan 06, 15:45	2,810	3,010
16 Nov 06, 18:45	2,620	2,850
22 Feb 08, 23:30	1,410	1,630

Table J-A-13. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Uchee Creek Gage (322)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
03 Apr 47, 24:00	6,740	10,300
11 Jul 48, 24:00	8,400	13,000
27 Nov 48, 24:00	13,000	25,000
07 Mar 50, 24:00	4,200	4,270
23 Apr 51, 24:00	1,320	1,860
25 Mar 52, 24:00	10,300	11,900
01 May 53, 24:00	7,650	9,290
05 Dec 53, 24:00	8,550	9,740
12 Jul 55, 24:00	4,140	5,310
17 Mar 56, 24:00	3,880	4,680
06 Apr 57, 24:00	7,830	11,600
08 Mar 58, 24:00	15,700	21,100
06 Mar 59, 24:00	3,200	3,200
03 Apr 60, 24:00	6,400	9,400
25 Feb 61, 24:00	12,000	14,800
13 Apr 62, 24:00	5,710	7,430
21 Jan 63, 24:00	4,800	4,800
09 Apr 64, 24:00	27,400	55,100
06 Oct 64, 24:00	6,780	10,200
04 Mar 66, 24:00	14,000	16,500
02 Jan 67, 24:00	4,200	4,720
13 Mar 68, 24:00	6,660	8,910
19 Apr 69, 24:00	8,500	11,200
21 Mar 70, 24:00	5,020	5,660
04 Mar 71, 24:00	9,870	13,500
13 Jan 72, 24:00	1,910	3,480
22 Dec 72, 24:00	9,000	11,200
05 Apr 74, 24:00	4,050	4,430
15 Apr 75, 24:00	8,530	10,100
01 Apr 76, 24:00	7,490	9,380
08 Oct 76, 24:00	5,900	8,630
26 Jan 78, 24:00	14,200	15,700
05 Apr 79, 24:00	9,560	12,800
14 Apr 80, 24:00	6,200	7,350
02 Apr 81, 24:00	13,600	18,500
04 Feb 82, 24:00	6,740	8,910
06 Mar 83, 24:00	7,230	9,850
26 Mar 84, 24:00	3,850	5,530
07 Feb 85, 24:00	3,110	4,510
19 Mar 86, 24:00	3,260	6,200
28 Feb 87, 24:00	6,690	8,430
03 Feb 88, 24:00	1,310	4,580
04 Jul 89, 24:00	8,510	9,750
17 Mar 90, 24:00	19,500	24,900
30 Mar 91, 24:00	10,100	12,500
14 Jan 92, 24:00	5,710	6,720
26 Nov 92, 24:00	18,500	26,900
08 Jul 94, 24:00	18,500	25,600
18 Feb 95, 24:00	5,500	6,180
05 Oct 95, 24:00	6,680	9,640
28 Apr 97, 24:00	7,670	9,970
09 Mar 98, 24:00	16,100	18,200
01 Feb 99, 24:00	3,400	3,620
20 Mar 00, 24:00	3,720	4,730
04 Mar 01, 24:00	12,400	15,200
07 Feb 02, 24:00	1,460	1,600
02 Jul 03, 24:00	6,490	8,270
17 Sep 04, 24:00	3,220	3,650
28 Mar 05, 24:00	12,500	15,000
26 Feb 06, 24:00	4,550	5,030
02 Mar 07, 24:00	4,340	6,460

Table J-A-14. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Upatoi Creek Gage (342)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
18 Apr 69, 24:00	4,480	8,850
21 Mar 70, 24:00	5,390	6,800
03 Mar 71, 24:00	6,340	8,940
27 Jun 72, 24:00	1,910	4,310
07 Apr 73, 24:00	3,200	7,570
04 Apr 74, 24:00	1,790	6,070
15 Apr 75, 24:00	8,670	10,200
04 Jun 76, 24:00	2,130	3,990
03 Aug 77, 24:00	2,810	6,440
25 Jan 78, 24:00	5,260	7,350
24 Feb 79, 24:00	5,970	7,770
30 Mar 80, 24:00	4,520	5,630
01 Apr 81, 24:00	9,620	17,300
03 Feb 82, 24:00	4,190	6,730
11 Dec 82, 24:00	1,460	4,700
06 Mar 84, 24:00	3,030	3,650
06 Feb 85, 24:00	3,380	4,180
14 Mar 86, 24:00	7,510	9,790
01 Mar 87, 24:00	4,260	5,740
20 Jan 88, 24:00	2,170	3,330
06 Mar 89, 24:00	2,610	3,830
17 Mar 90, 24:00	31,600	46,300
29 Mar 91, 24:00	2,740	8,300
17 Feb 92, 24:00	1,960	4,050
26 Nov 92, 24:00	7,050	8,170
06 Jul 94, 24:00	6,310	6,690
18 Feb 95, 24:00	4,640	5,510
07 Mar 96, 24:00	7,160	9,440
22 Feb 97, 05:15	2,980	3,810
08 Mar 98, 22:30	12,500	16,700
01 Feb 99, 15:00	1,700	2,340
20 Mar 00, 09:15	2,710	4,090
04 Mar 01, 05:00	7,350	8,330
07 Feb 02, 05:00	1,670	1,880
07 Mar 03, 15:45	3,370	5,150
17 Sep 04, 17:45	3,550	4,040
27 Mar 05, 18:45	7,360	10,200
26 Feb 06, 05:30	2,880	3,480
02 Mar 07, 08:00	4,010	4,880
18 Feb 08, 08:00	2,480	3,710

Appendix J-B

Development of Unimpaired Peak Flow Frequencies at Columbus

Appendix J-B

Unimpaired Peak Flow Frequency Curves at Columbus

The USACE Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) was used to compute the 1-day, 3-day, 5-day, and 45-day unimpaired volume frequency curves at Columbus from the daily unimpaired data set for the period of record from 1939 through 2007. The 1-day maximum flows were then converted to instantaneous maximum flows using the instantaneous peak flow vs. daily average flow relationship shown in Figure J-B.01. Next, the unimpaired instantaneous peak flows were imported into HEC-SSP and a General Frequency Analysis was performed. Currently, there is no option in HEC-SSP to plot results from Volume-Duration and Bulletin 17B analyses on one graph; therefore, a spreadsheet was developed that used the output from HEC-SSP to plot the frequency curves on one graph. The 1-day annual maximum and instantaneous peak flows are provided in Table J-B-01. The instantaneous, 1-day, 3-day, 5-day, and 45-day unimpaired frequency curves are contained in Table J-B-02 and are shown in Figure J-B.02. The 45-day frequency was selected in order to capture multiple peak events.

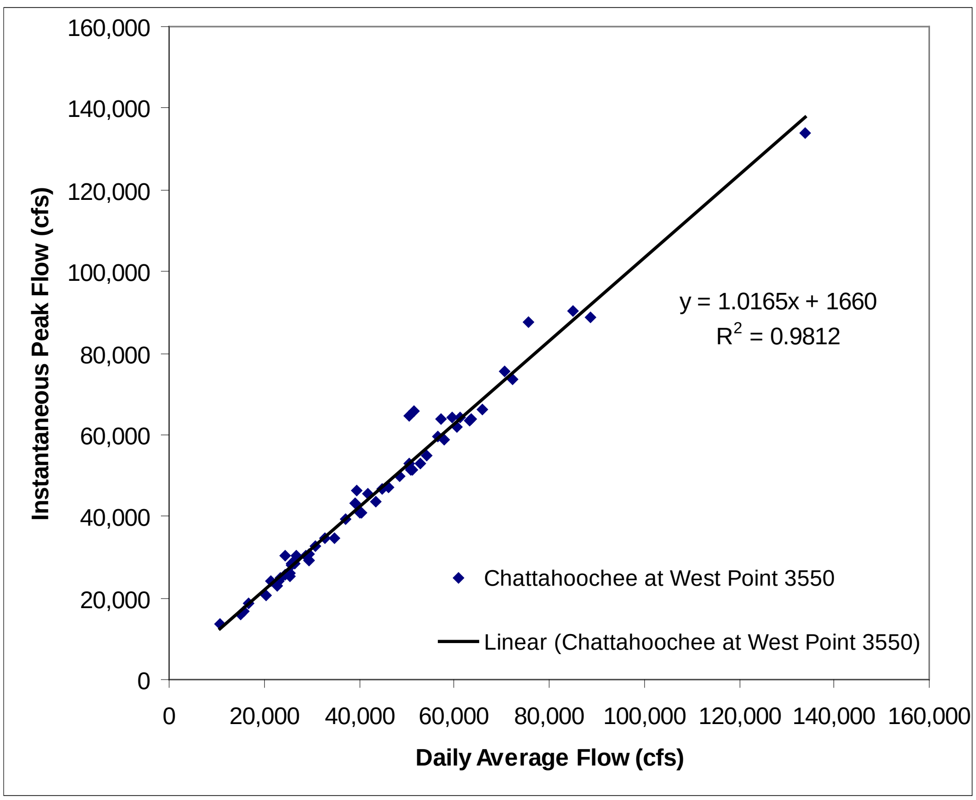

Figure J-B.01 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

Table J-B-01. 1-Day and Instantaneous Peak Flows at Columbus

Date	1-Day Annual Maximum CFS	Instantaneous Annual Peak (Compute) CFS
10 Jul 40, 24:00	32,201	34,393
26 Dec 41, 24:00	26,030	28,119
22 Mar 42, 24:00	76,928	79,858
22 Mar 43, 24:00	77,466	80,404
27 Apr 44, 24:00	51,497	54,006
26 Apr 45, 24:00	74,430	77,318
12 Jan 46, 24:00	69,133	71,934
21 Jan 47, 24:00	57,951	60,567
29 Nov 48, 24:00	76,936	79,865
30 Apr 49, 24:00	49,316	51,790
16 Mar 50, 24:00	18,789	20,759
22 Dec 51, 24:00	45,730	48,144
05 Mar 52, 24:00	50,142	52,629
10 Jan 53, 24:00	31,425	33,603
20 Jan 54, 24:00	29,962	32,117
08 Feb 55, 24:00	28,733	30,867
17 Mar 56, 24:00	52,262	54,784
06 Apr 57, 24:00	59,229	61,866
07 Feb 58, 24:00	41,085	43,423
02 Jun 59, 24:00	37,563	39,842
04 Apr 60, 24:00	39,270	41,578
26 Feb 61, 24:00	117,260	120,855
24 Feb 62, 24:00	43,559	45,937
02 May 63, 24:00	55,243	57,814
08 Apr 64, 24:00	74,229	77,113
24 Jan 65, 24:00	43,115	45,486
15 Feb 66, 24:00	58,455	61,080
26 Aug 67, 24:00	51,698	54,211
13 Mar 68, 24:00	39,214	41,521
19 Apr 69, 24:00	58,025	60,642
22 Mar 70, 24:00	62,720	65,415
04 Mar 71, 24:00	73,087	75,953
12 Jan 72, 24:00	78,571	81,528
03 Feb 73, 24:00	50,543	53,037
03 Jan 74, 24:00	46,395	48,821
16 Mar 75, 24:00	46,091	48,511
17 Mar 76, 24:00	72,065	74,914
01 Apr 77, 24:00	62,403	65,092
26 Jan 78, 24:00	55,837	58,419
14 Apr 79, 24:00	79,878	82,856
09 Mar 80, 24:00	46,091	48,511
11 Feb 81, 24:00	42,204	44,561
04 Feb 82, 24:00	67,205	69,974
09 Apr 83, 24:00	53,963	56,513
01 Aug 84, 24:00	34,372	36,599
06 Feb 85, 24:00	37,739	40,022
27 Nov 86, 24:00	18,374	20,338
02 Mar 87, 24:00	40,219	42,542
21 Jan 88, 24:00	29,484	31,630
03 Oct 89, 24:00	65,483	68,224

… Continued …

Table J-B-01. 1-Day and Instantaneous Peak Flows at Columbus *(Continued)*

Date	1-Day Annual Maximum CFS	Instantaneous Annual Peak (Compute) CFS
17 Mar 90, 24:00	101,823	105,164
06 May 91, 24:00	28,969	31,107
26 Nov 92, 24:00	66,050	68,800
14 Jan 93, 24:00	33,507	35,720
05 Jul 94, 24:00	51,354	53,862
06 Oct 95, 24:00	58,393	61,016
08 Mar 96, 24:00	78,590	81,546
01 Mar 97, 24:00	60,602	63,262
09 Mar 98, 24:00	95,247	98,478
01 Feb 99, 24:00	23,808	25,861
04 Apr 00, 24:00	22,178	24,204
04 Mar 01, 24:00	50,273	52,763
25 Dec 02, 24:00	32,270	34,463
08 May 03, 24:00	119,322	122,951
18 Sep 04, 24:00	40,009	42,329
01 Apr 05, 24:00	67,571	70,346
21 Mar 06, 24:00	27,923	30,044
02 Mar 07, 24:00	23,881	25,935

Table J-B-02. Peak, 1-Day, 3-Day, 5-Day, and 45-Day Frequency Curves at Columbus

Frequency	Peak	1-Day	3-Day	5-Day	45-Day
99.0	18213	17286	15251	13501	5891
95.0	25156	23875	20851	18136	7774
90.0	29729	28216	24547	21180	8973
80.0	36220	34377	29810	25506	10630
50.0	52101	49449	42801	36171	14520
20.0	73577	69833	60666	50887	19518
10.0	87490	83037	72432	60634	22638
5.0	100571	95453	83633	69962	25506
2.0	117185	111221	98050	82044	29071
1.0	129461	122872	108840	91143	31656
0.5	141594	134388	119616	100280	34176
0.2	157511	149495	133923	112487	37434
0.1	169509	160883	144831	121852	39857

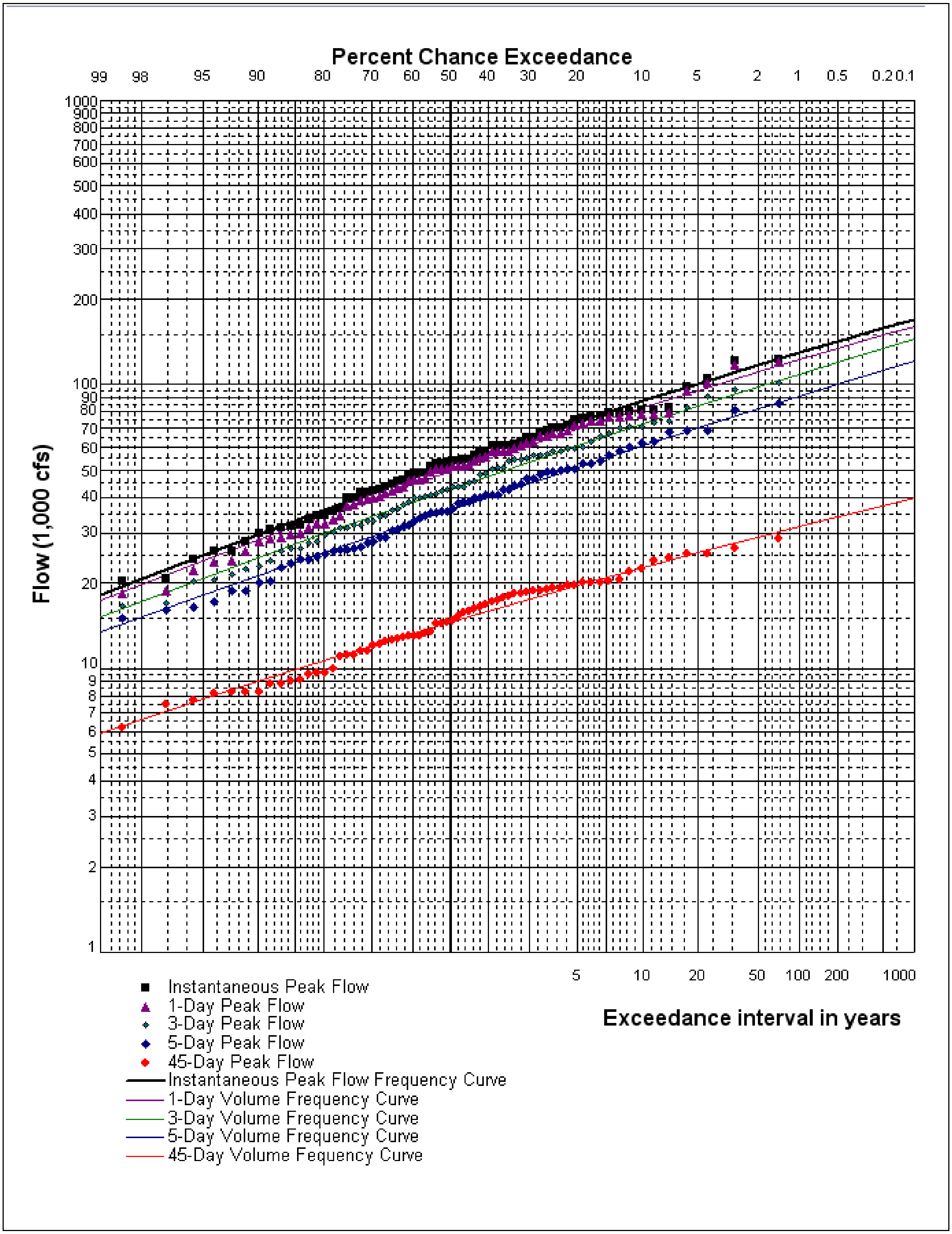

Figure J-B.02 Peak, 1-Day, 3-Day, 5-Day, and 45-Day Frequency Curves at Columbus

Appendix J-C

Conversion of Daily Average Unimpaired Data to Hourly Values

Appendix J-C

Conversion of Historic Storm Events from Daily to Hourly Flows

Hourly unimpaired flow hydrographs were developed for the March 1990 and May 2003 storm events. HEC staff performed the analysis for the May 2003 event and the USACE Mobile District staff performed the analysis for the March 1990 event. The initial analysis performed by HEC for the May 2003 event extended from Buford Dam to Columbus. However, unimpaired hourly hypothetical storm hydrographs were only needed from West Point Reservoir to Columbus; therefore, the analysis performed by the Mobile District for the March 1990 event only included the reach from West Point R to Columbus. Details of the development of hourly unimpaired flows for the two events are shown below. Results of this analysis were used as input into a HEC-HMS model to produce the computed hourly unimpaired flow at all the model junctions.

May 2003 Storm Event:
Hourly unimpaired flow hydrographs were developed by HEC staff from Buford Dam to Columbus for the May 2003 storm event. These hourly flows were computed from the daily unimpaired data which contained daily hydrographs for all flow sources and junctions on the ACF River system. The flow sources and junctions from Buford Dam to Columbus are shown in Figure J-C.01.

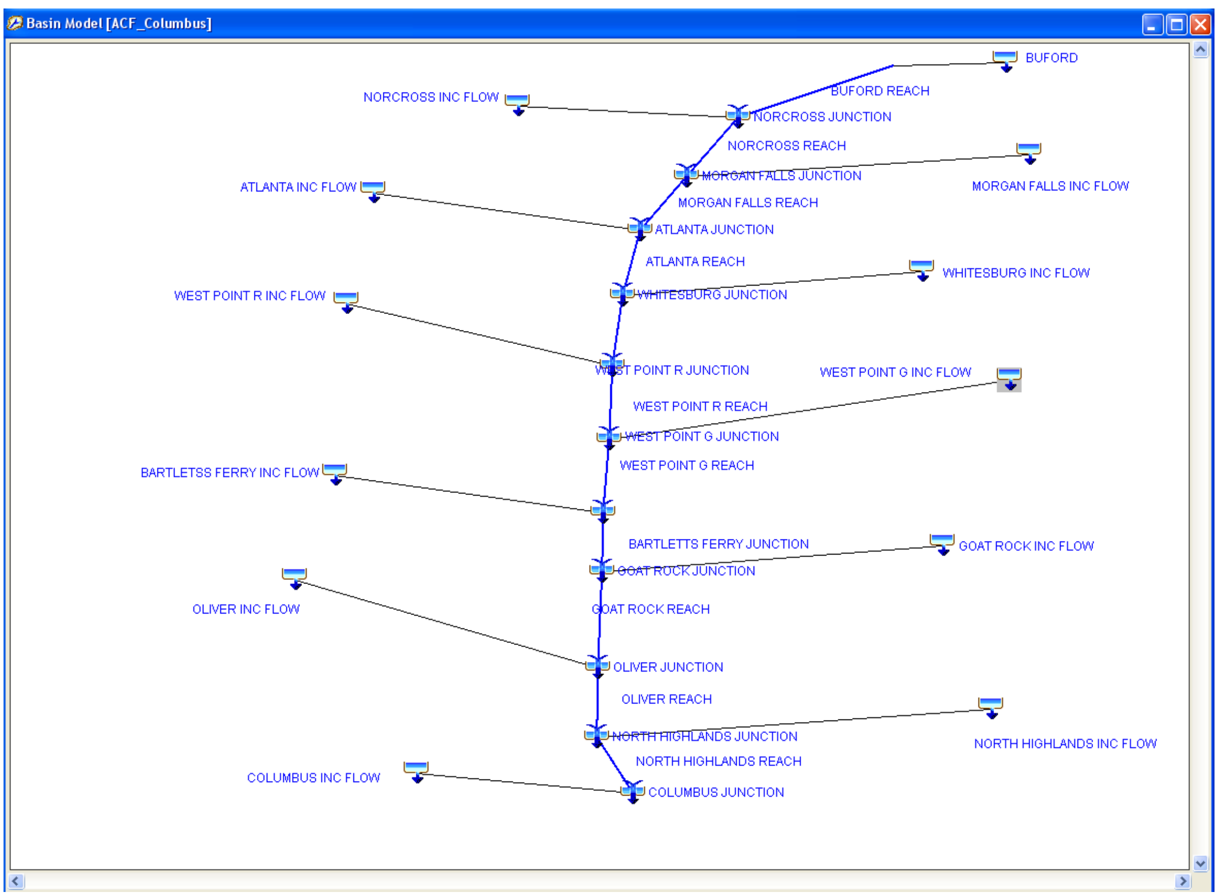

Figure J-C.01 ACF Schematic from Buford Dam to Columbus

Appendix J-C: Conversion of Daily Data to Hourly Values

There were twelve flow sources and eleven junctions from Buford Dam to Columbus where hourly flows were developed. The instantaneous hydrograph peak values were determined using the instantaneous vs. daily average flow relationships discussed in Section 2.1 and a SCS unit hydrograph was used to shape the hydrograph around the peak. The rising and falling limbs of the hydrographs were shaped using a combination of power and exponential equations. The volumes of the daily and hourly hydrographs were compared to ensure that the volumes were preserved. The daily and hourly hydrographs for the May 2003 event at Columbus is shown in Figure J-C.02. Notice that only the largest flood hydrographs were converted to a "true" hourly hydrographs. The hourly flows for the rest of the time window were computed by interpolating the daily average flows.

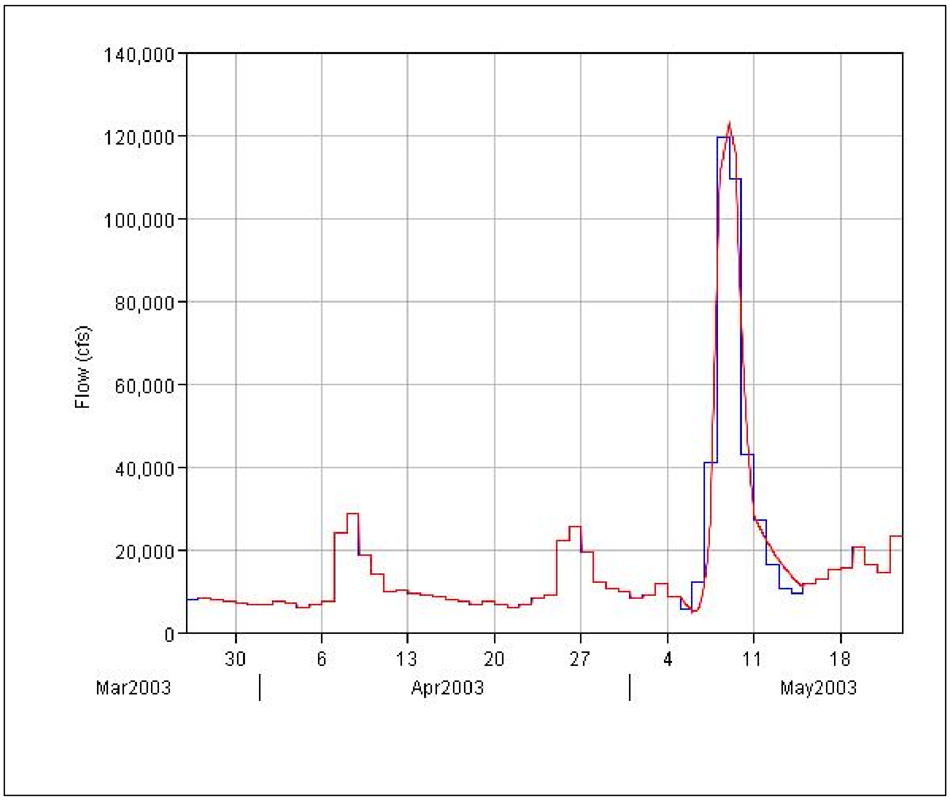

Figure J-C.02 May 2003 Daily vs. Hourly Storm Hydrographs at Columbus

March 1990 Storm Event:
Hourly unimpaired flow hydrographs were developed for the March 1990 storm event from West Point Reservoir (West Point R) to Columbus. A schematic of this reach is shown in Figure J-C.03.

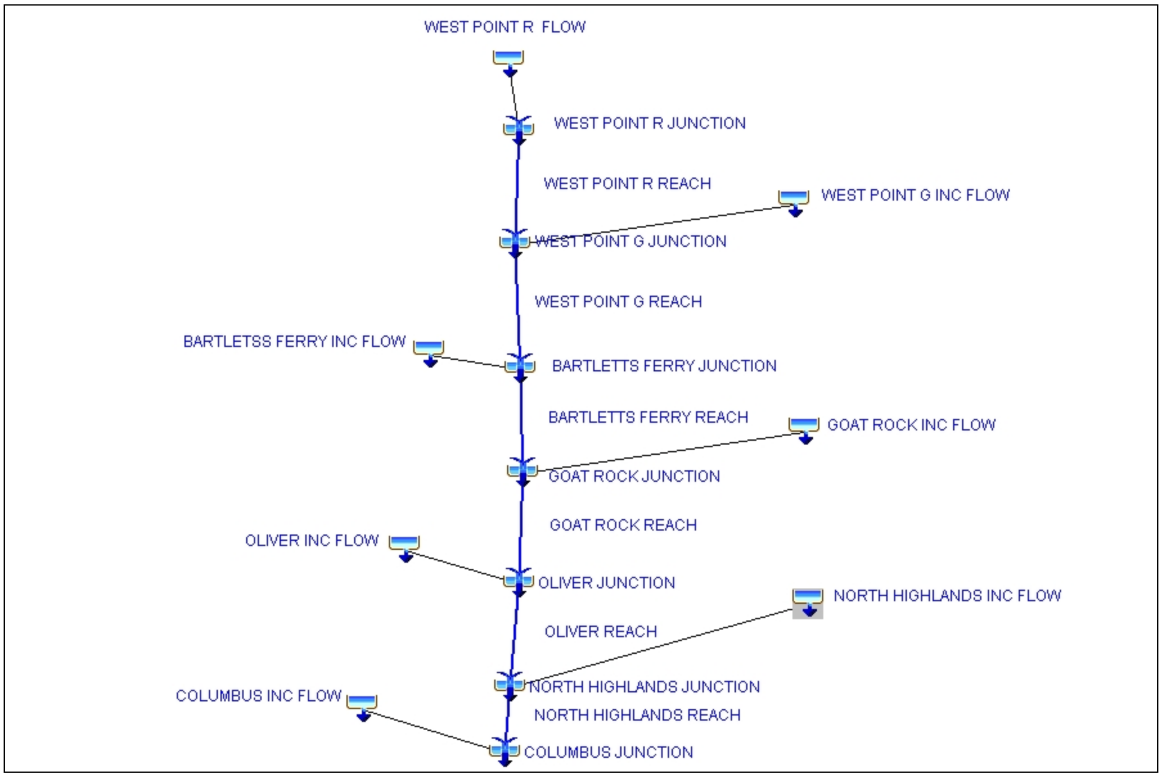

Figure J-C.03 ACF Model Node Schematic

There were seven flow sources and seven junctions from West Point R to Columbus where hourly flows were developed. The inflow to the reach (West Point R flow) and the flow at the seven junctions were developed using the same methodology as the May 2003 event. This process was also attempted for the computation of the March local flow hydrographs. However, it resulted in an approximately 15-percent increase in the HEC-HMS computed peak flow at Columbus and, therefore, another approach was used. The daily and hourly hydrographs developed at the Columbus junction for the March 1990 event are shown in Figure J-C.04.

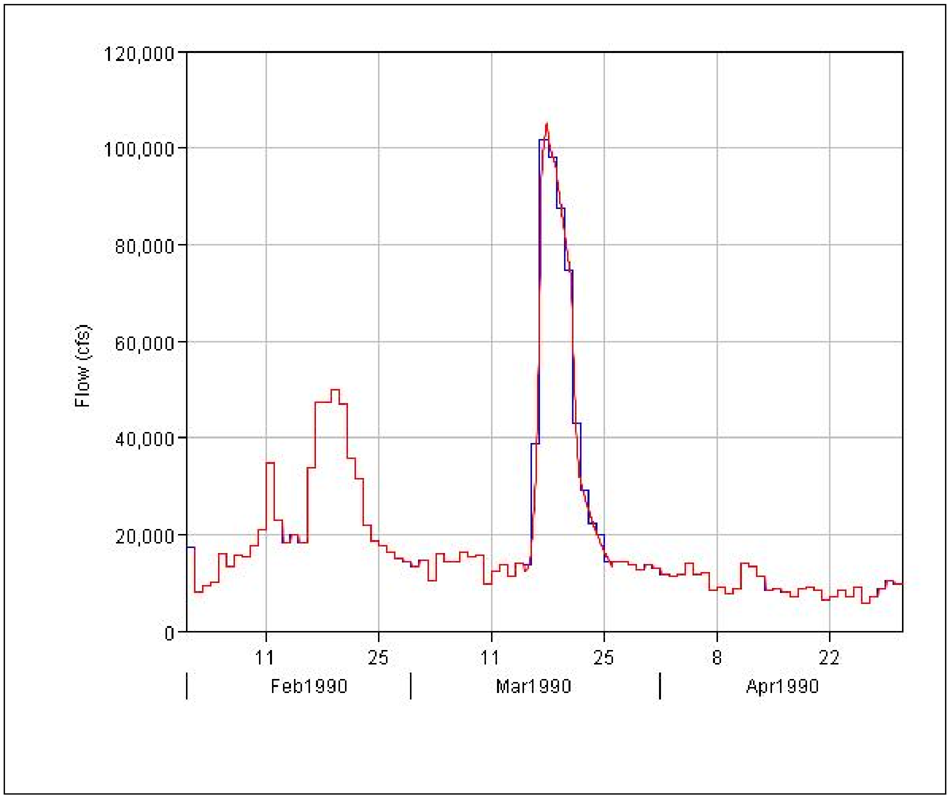

Figure J-C.04 March 1990 Daily vs. Hourly Storm Hydrographs at Columbus

The local flows for the March 1990 event were developed by routing the hourly hydrographs at the junctions downstream and subtracting the routed hydrograph from the flow at the downstream node. The routing parameters used in the analysis were determined from the calibrated HEC-HMS model for the 2003 event. The hourly flow at Columbus and routed flow from North Highlands is shown in Figure J-C.05. The resulting local flow determined by subtracting the two hydrographs is provided in Figure J-C.06. Details of the routing parameters and HEC-HMS model calibration are provided in Appendix J-D.

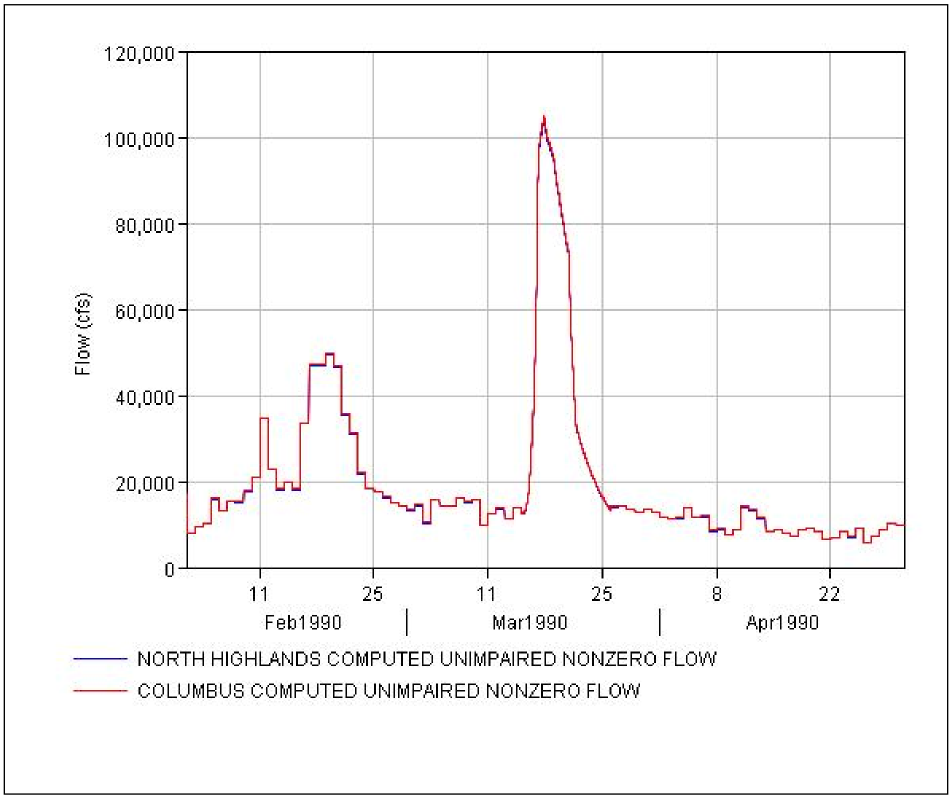

Figure J-C.05 Hourly flow at Columbus and Routed Hourly Flow from North Highlands for March 1990 Event

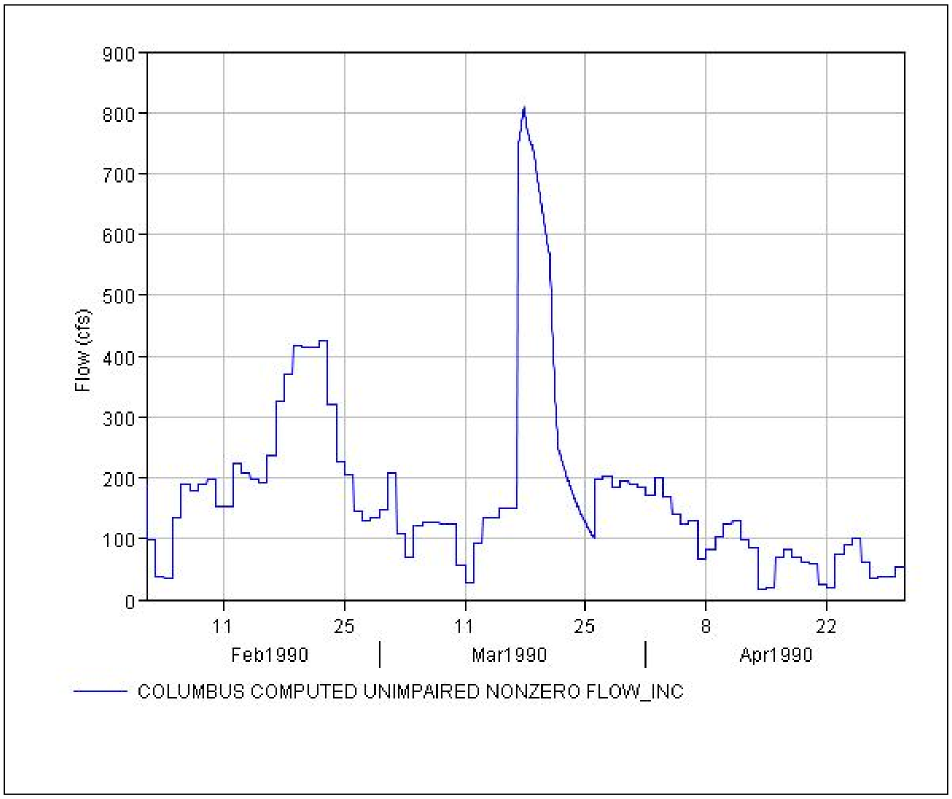

Figure J-C.06 Hourly Local Flow at Columbus for March 1990 Event

Appendix J-D

Development and Calibration of HEC-HMS Model

Appendix J-D

Development and Calibration of HEC-HMS Model

Two HEC-HMS models were developed for the ACF River system above Columbus. The first model was created by the USACE Hydrologic Engineering Center (HEC) and second model was created by the USACE Mobile District. The initial model created by HEC extended from Buford Dam to Columbus and consisted of twelve flow sources, eleven junctions, an eleven routing reaches. The model developed by USACE Mobile District was an abbreviated version of HEC's model and extended from West Point Reservoir (West Point R) to Columbus. It contained seven flow sources, seven junctions (nodes), and six routing reaches. The second model was developed due to the fact the unimpaired hourly flows were only needed from West Point R to Columbus. A schematic of the model developed by HEC is shown in Figure J-D.01. A schematic of the model developed by the Mobile District is provided in Figure J-D.02.

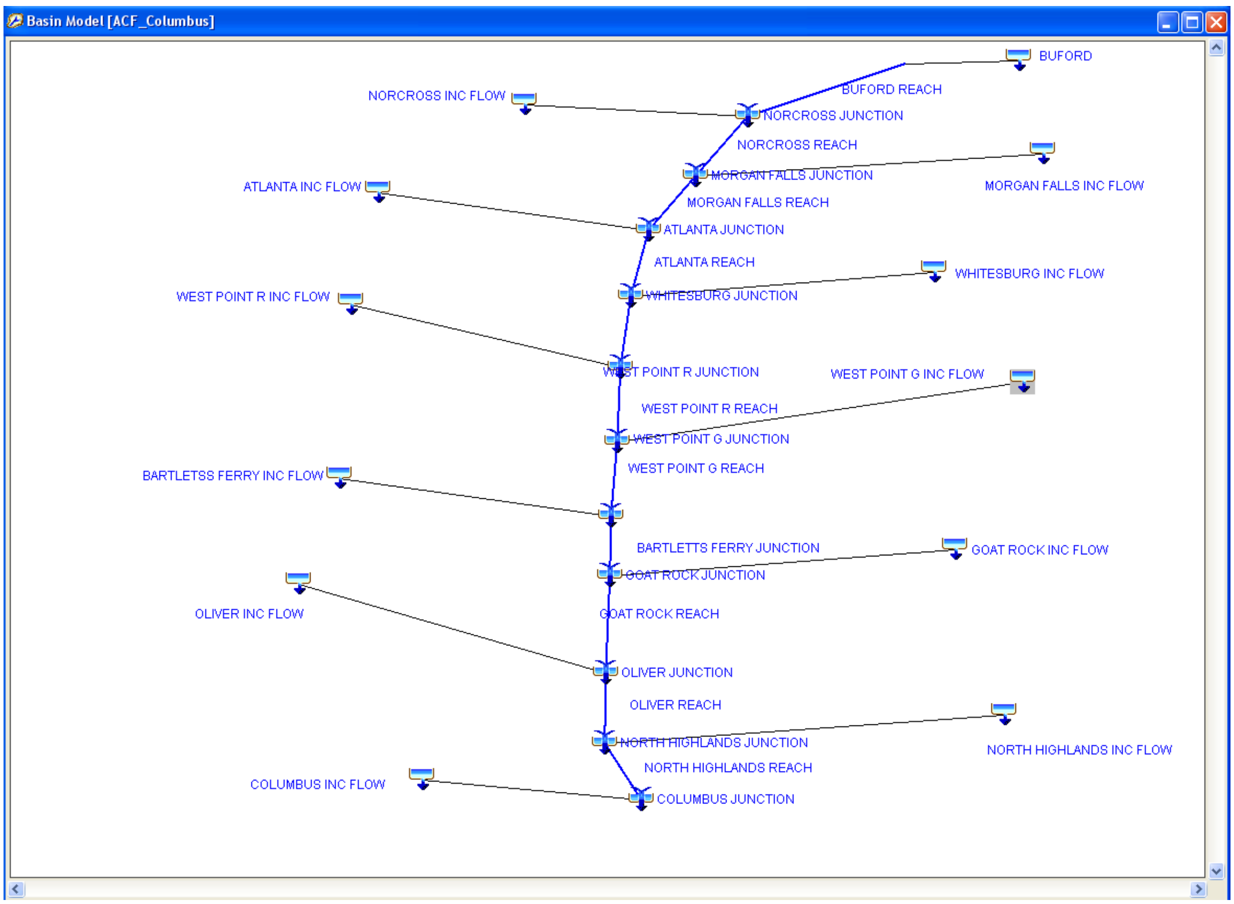

Figure J-D.01 Schematic of HEC-HMS Model from Buford Dam to Columbus Developed by HEC

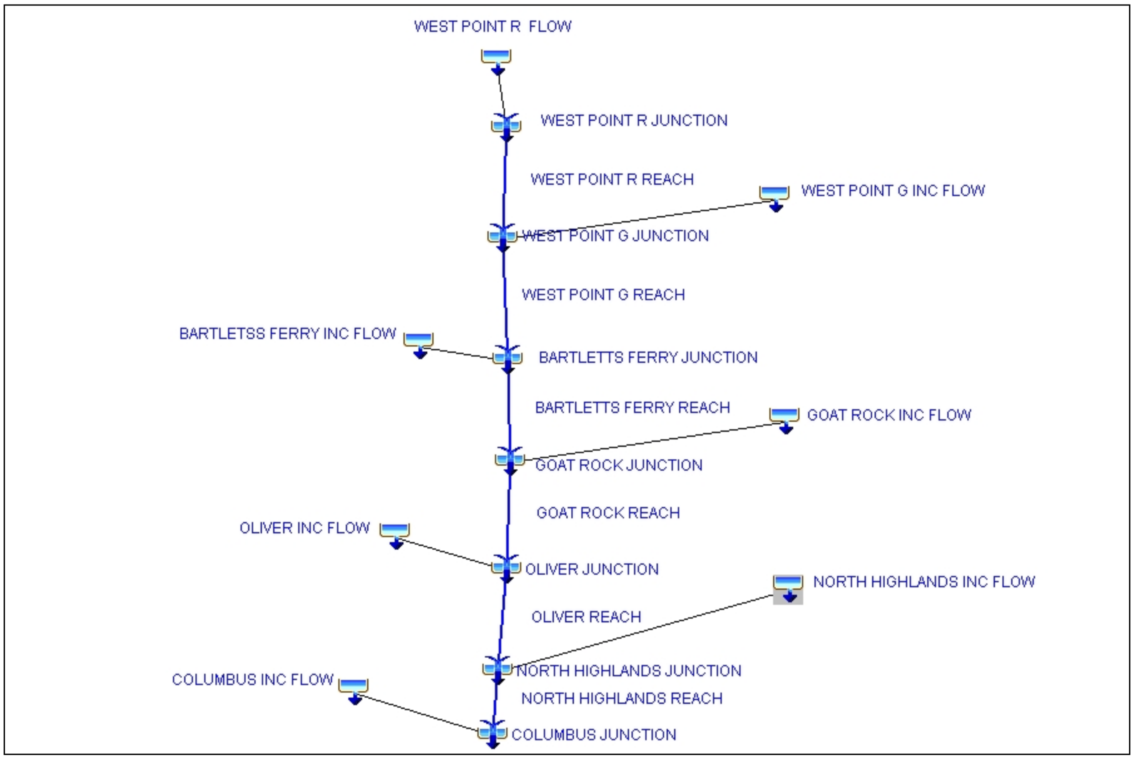

Figure J-D.02 Schematic of HEC-HMS Model from West Point R to Columbus Developed by the USACE Mobile District

The model developed by HEC was used to calibrate the routing parameters from Buford Dam to Columbus. The hourly local hydrographs at all eleven node locations as well as the hourly unimpaired inflow to Buford Dam were input into the HEC-HMS model and routed downstream. The Muskingum routing parameters were adjusted until the HEC-HMS model hydrograph matched the computed unimpaired hourly hydrograph at Columbus. The final Muskingum routing parameters are shown in Table J-D-01. Figure J-D.03 shows the HEC-HMS model results at Columbus for the 2003 event. The model was able to reproduce the computed unregulated flow given the local runoff hydrographs and Muskingum routing parameters.

Table J-D-01. Muskingum Routing Parameters

Reach	Muskingum K	Muskingum X	Subreaches
Buford	12	0.0	1
Norcross	16	0.0	1
Morgan Falls	2	0.0	1
Atlanta	30	0.0	1
Whitesburg	20	0.0	1
West Point R	1	0.0	1
West Point G	5	0.0	1
Bartletts Ferry	No Routing Used		
Goat Rock	1	0	1
Oliver	No Routing Used		
North Highlands	No Routing Used		

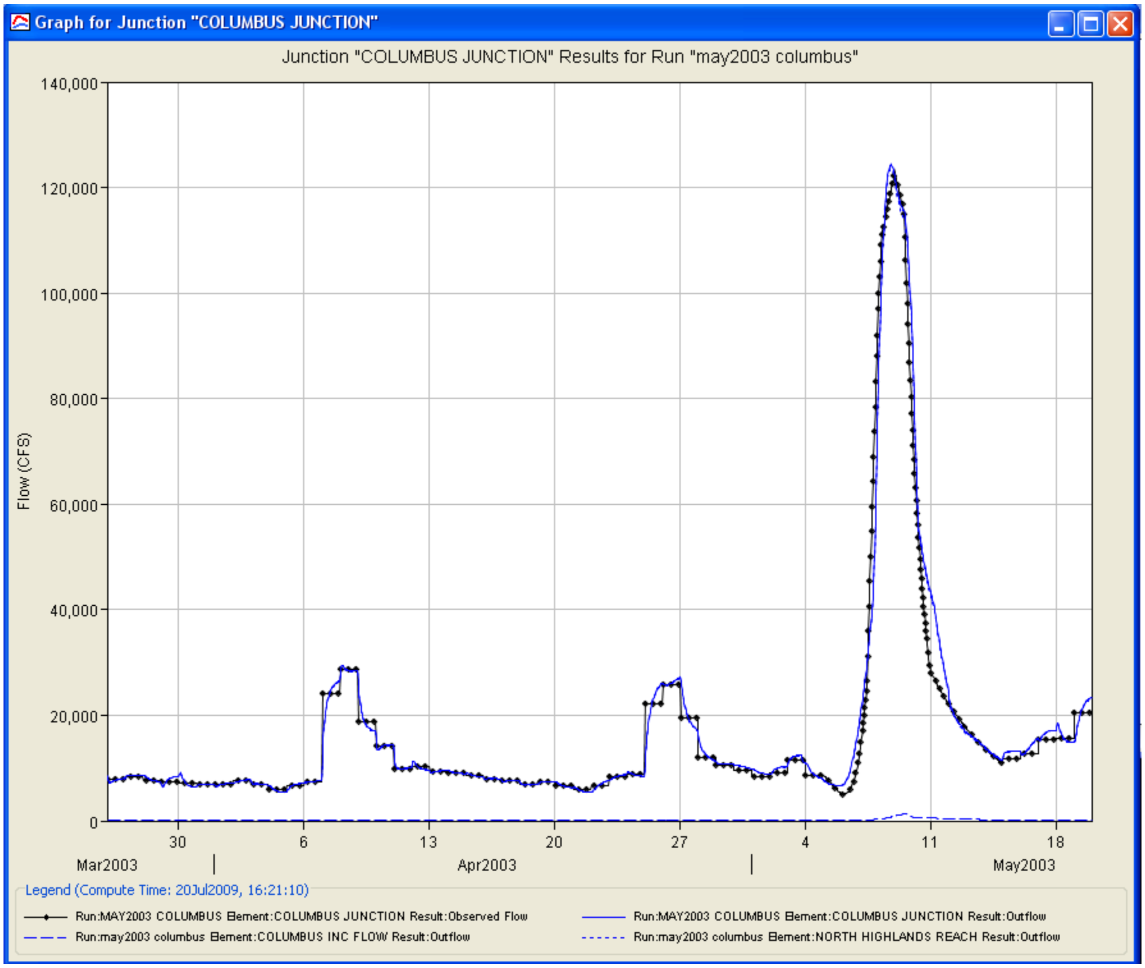

Figure J-D.03 HEC-HMS Model Results at Columbus for the May 2003 Event

The routing parameters shown in Table J-D-01 were used in the HEC-HMS model developed by the Mobile District for the March 1990 event. This model only included the reach from West Point R to Columbus. The results of the March 1990 modeling effort are provided in Figure J-D.04. This model was also able to reproduce the computed unregulated flow given the local runoff hydrographs and Muskingum routing parameters.

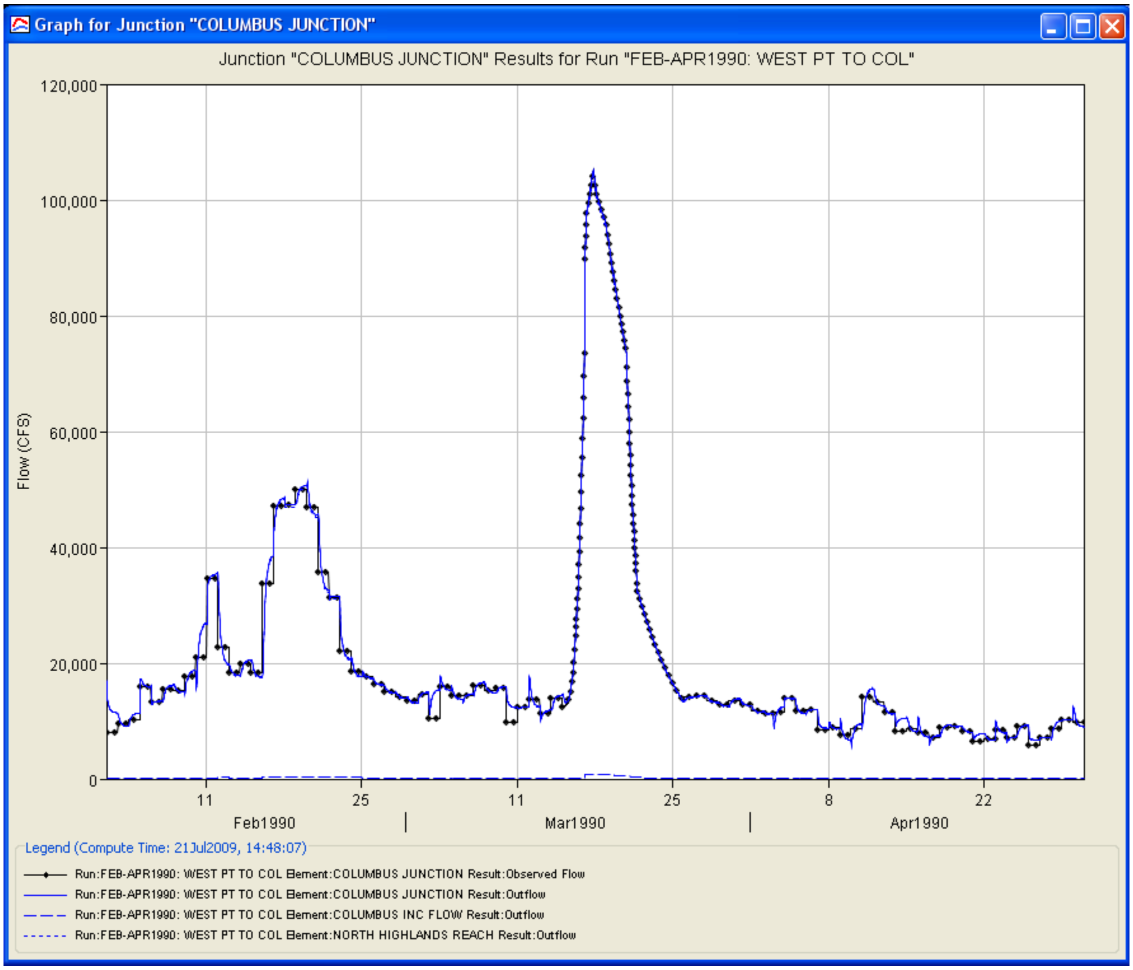

Figure J-D.04 HEC-HMS Model Results at Columbus for the March 1990 Event

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Appendix K – Development of Alternatives

June 2014

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Appendix K – Development of Alternatives

Table of Contents:

List of Tables:

List of Figures:

Development of Alternatives
(in the ACF 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 ACF Master Water Control Manual. 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 ACF project used to simulate the alternatives.

The ACF system contains 12 projects. These 12 projects are modeled in the HEC-ResSim model of the system. The projects included in the ResSim model are as follows:

1) Glades
2) Buford
3) Morgan Falls
4) Bear Creek
5) West Point
6) Bartletts Ferry
7) Goat Rock
8) Oliver
9) North Highlands
10) Walter F George
11) George Andrews
12) Jim Woodruff

Various operation sets were modeled to study the operating alternatives on the ACF system. These operation sets will be described in detail in this document. There are 8 alternatives in the model. The alternatives are as follows:

1) NOAction
2) Alt1
3) Alt2
4) Alt3
5) Alt4
6) Alt5
7) Alt6
8) Alt7

NOAction alternative does not include Glades and Bear Creek reservoirs. This alternative is created based on network named “2014_Base”. The rest of the alternatives include all 12 mentioned projects and they are based on “2014” network.

There are 7 operation sets in the model. The operation sets are as follows:

1) NO-Action
2) Silver
3) Crimson
4) Orange
5) Peach
6) Blue
7) Gold

Table K.01 shows the alternative matrix with relevant operation sets per Alternative and Reservoir.

Table K.01 Matrix of Alternative/Operation Sets (by Reservoir)

<table>
<tr><th rowspan="2"></th><th colspan="8">Alternatives</th></tr>
<tr><th>NOAction</th><th>Alt1</th><th>Alt2</th><th>Alt3</th><th>Alt4</th><th>Alt5</th><th>Alt6</th><th>Alt7</th></tr>
<tr><td>Glades</td><td></td><td colspan="7">NO-Action</td></tr>
<tr><td>Buford</td><td colspan="2">NO-Action</td><td colspan="4">Silver</td><td>Blue</td><td>Gold</td></tr>
<tr><td>Morgan Falls</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>Bear Creek</td><td></td><td colspan="7">NO-Action</td></tr>
<tr><td>West Point</td><td colspan="2">NO-Action</td><td colspan="6">Silver</td></tr>
<tr><td>Bartletts Ferry</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>Goat Rock</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>Oliver</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>North Highlands</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>Walter F George</td><td colspan="2">NO-Action</td><td colspan="6">Silver</td></tr>
<tr><td>George Andrews</td><td colspan="8">Flow-Thru</td></tr>
<tr><td>Jim Woodruff</td><td colspan="2">NO-Action</td><td>Silver</td><td>Crimson</td><td>Orange</td><td>Peach</td><td>Blue</td><td>Gold</td></tr>
</table>

Table K.02 shows the measures selected for each alternative. The measures included variations for:

1) Revised action zones,
2) Revised hydropower generation
3) Development of navigation
4) Revised Basin Inflow
5) Revised minimum flow at Peach Tree Creek
6) Revised Flow Target
7) Revised Ramping Rate
8) Revised drought procedures
9) Revised Ramping Rate suspension

Table K.02 Measures Selected for Each Alternative

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

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

II. NOAction Alternative

Table K.03 shows the operation sets used in the NOAction alternative.

Table K.03 Operation Sets Used in NOAction Alternative

Project	Operation Set	Described Previously
Buford	NO-Action	No
Morgan Falls	NO-Action	No
West Point	NO-Action	No
Bartletts Ferry	Flow-thru	No
Goat Rock	Flow-thru	No
Oliver	Flow-thru	No
North Highlands	Flow-thru	No
Walter F George	NO-Action	No
George Andrews	Flow-thru	No
Jim Woodruff	NO-Action	No

A. Buford

The NO-Action operation set was used in the NOAction alternative at Buford. The project contains eight zones. The zones include Top of Dam, Flood Control, Conservation, Zone 2, Zone 3, Zone 4, Operating Inactive, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the NO-Action operation set for Buford is shown in Figure K.01.

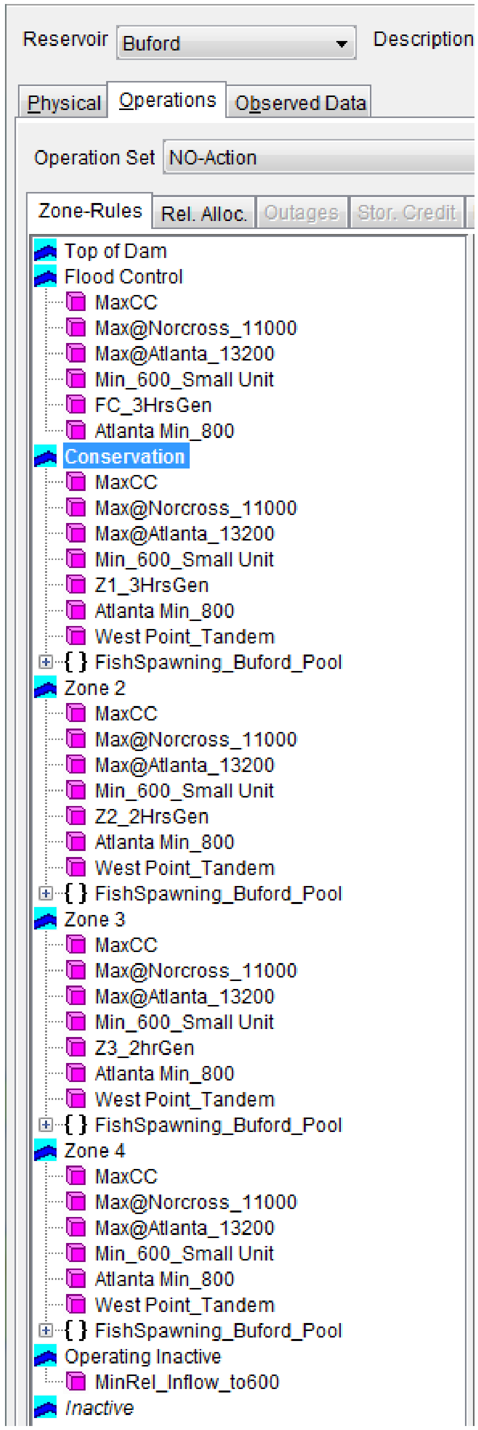


Figure K.01 Rule Set for Buford NO-Action Operation Set

1. MaxCC

This rule (see Figure K.02) sets a maximum release from Buford Dam to meet the channel capacity (10,000 cfs) for the Chattahoochee River just downstream of Buford Dam at Gage No. 02334430.

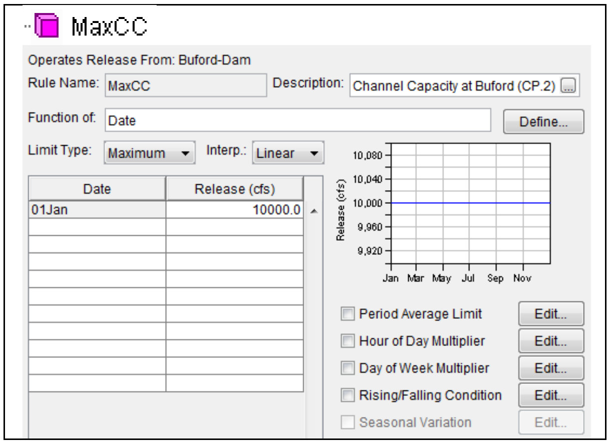


Figure K.02 *MaxCC* at Buford

2. Max@Norcross_11000

This rule (see Figure K.03) is a downstream control rule. It sets the channel capacity (11,000 cfs) for the Chattahoochee River at the Norcross streamflow gage location. A downstream maximum flow rule determines the release from the dam such that the sum of the reservoir release and all local inflows between the dam and the downstream control location does not exceed the specified maximum flow.

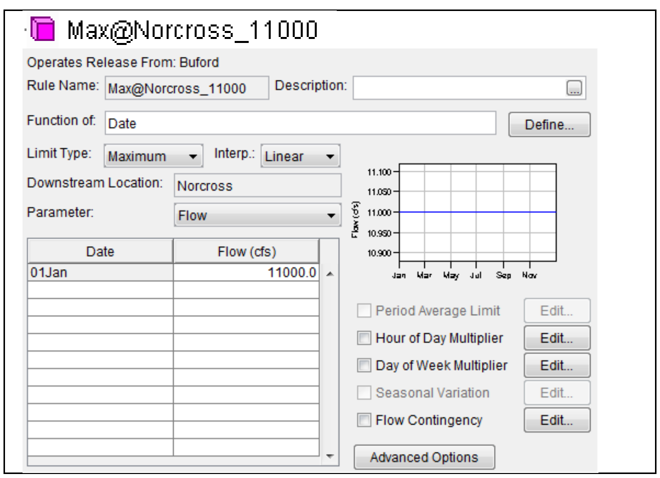


Figure K.03 *Max@Norcross_11000* at Buford

3. Max@Atlanta_13200

This rule (see Figure K.04) is a downstream control rule. It sets the channel capacity (13,200 cfs) for the Chattahoochee River at Atlanta streamflow gage location.

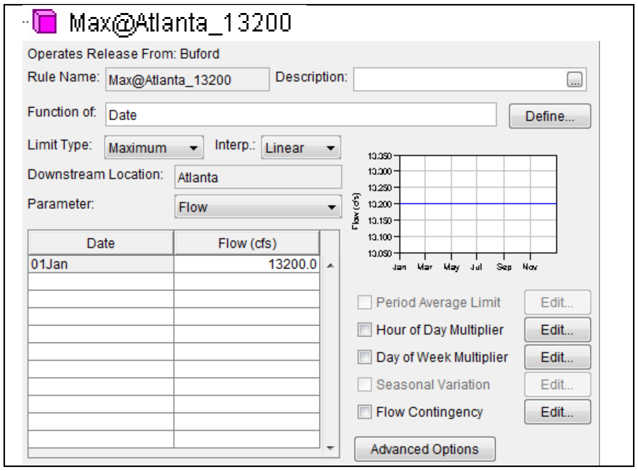


Figure K.04 *Max@Atlanta_13200* at Buford

4. Min_600_Small Unit

This rule (see Figure K.05) represents the flow release from the small unit, which is in use continuously throughout the year. Once the unit is on, the flow release is at approximately a constant of 600 cfs.

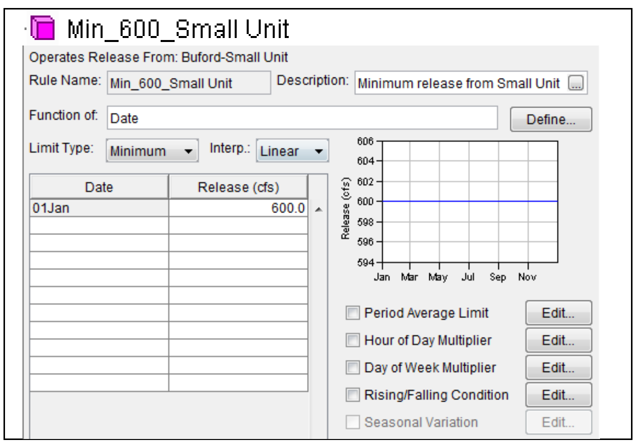


Figure K.05 *Min_600_Small Unit* at Buford

5. Atlanta Min_800

This rule (see Figure K.06) is to provide a minimum water quality flow of 750 cfs in the Chattahoochee just upstream from the junction with Peachtree Creek. The model uses 800 cfs to add a factor of safety to guarantee the minimum flow.

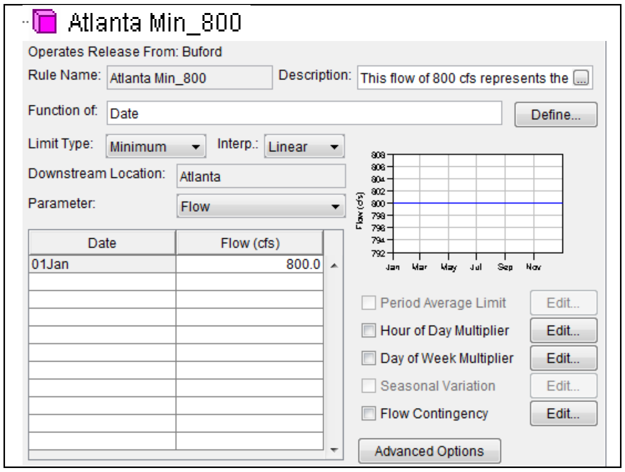


Figure K.06 ***Atlanta Min_800*** **at Buford**

6. MinRel_Inflow_to600

This rule (see Figure K.07) represents the release relationship between inflow to Lake Lanier and dam releases in the Operating Inactive zone. The rule sets the minimum release from Buford equal to the inflow for inflow values up to 600 cfs. For inflow values above 600 cfs, the minimum release remains at 600 cfs.

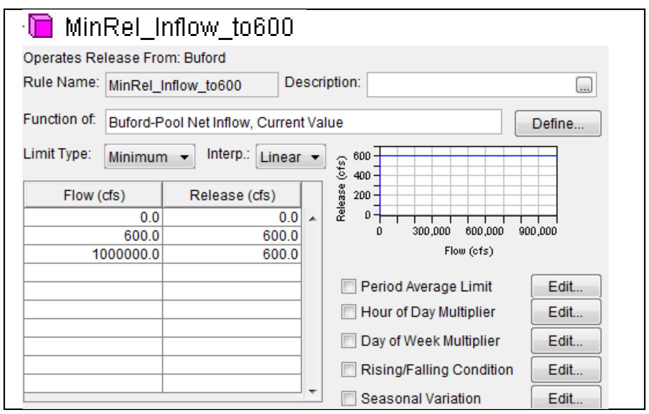


Figure K.07 ***MinRel_Inflow_to600*** **at Buford**

7. West Point_Tandem

This rule (see Figure K.08) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F George, and Lake Seminole to meet the Endangered Species Act requirements on the Apalachicola River.

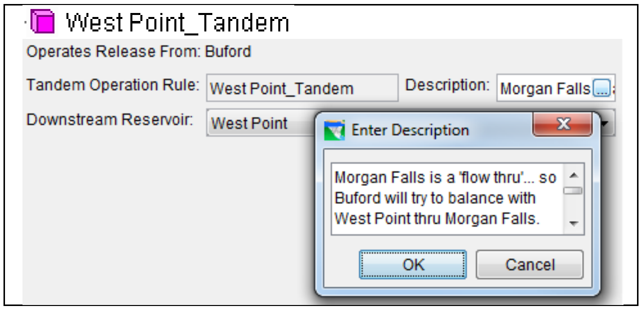
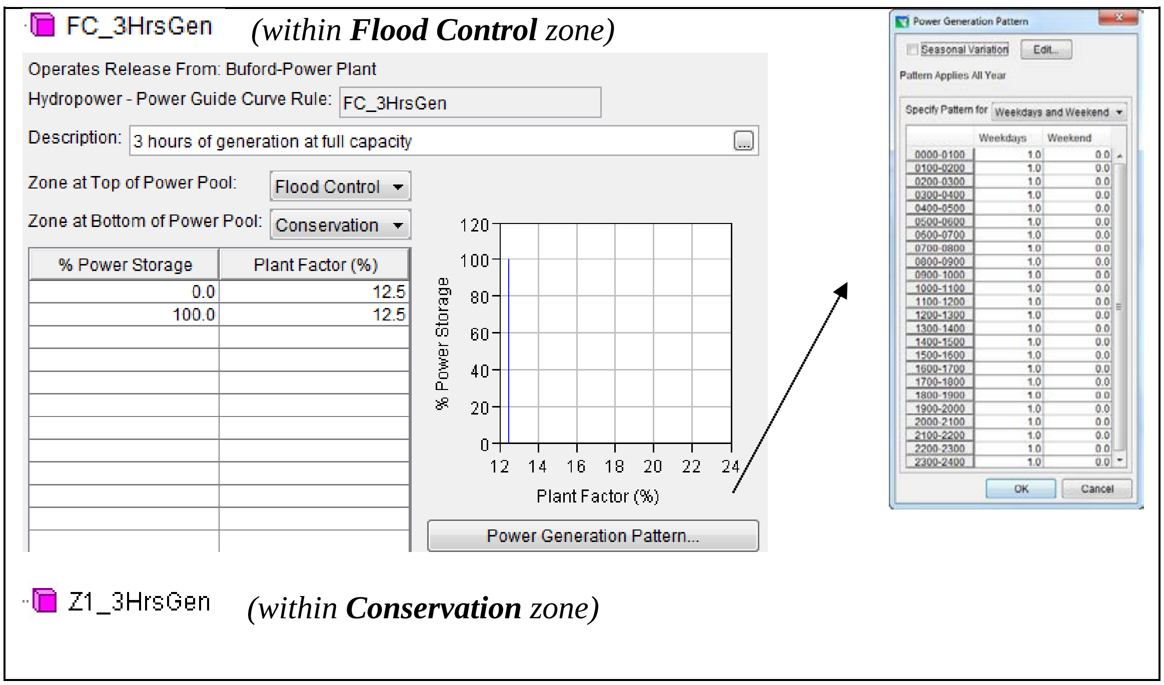


Figure K.08 *West Point_Tandem* at Buford

8. FC-3HrsGen, Z1_3HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure K.09) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor. This parameter is a function of storage and specific hours of generation (2 or 3 hours) that vary by zone.



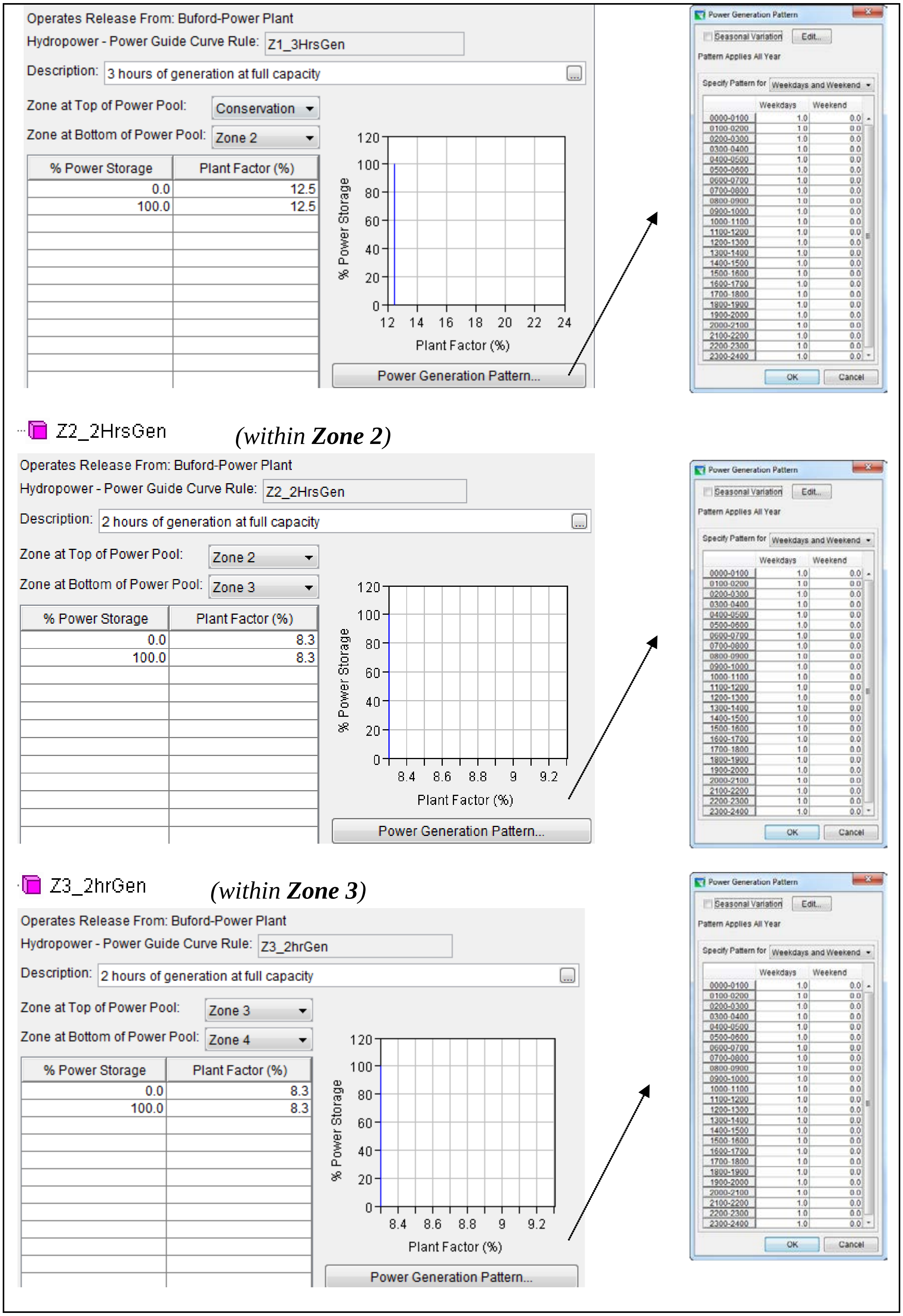


Figure K.09 Hydropower Rules at Buford

9. Fish Spawning_Buford

The IF-Blocks and rules (see Figure K.10 through Figure K.13) 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 April 1 through May 31 for Lake Sidney Lanier, 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 H.

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 state variable *Buford_Elev_State* script is used for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator. The lake elevation state is defined as follows:

```
# State variable: Buford_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
```

The state variable *Buford_Elev_State* script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is further described in Appendix H.

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 K.14 and Figure K.15). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure K.16 and Figure K.17):

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

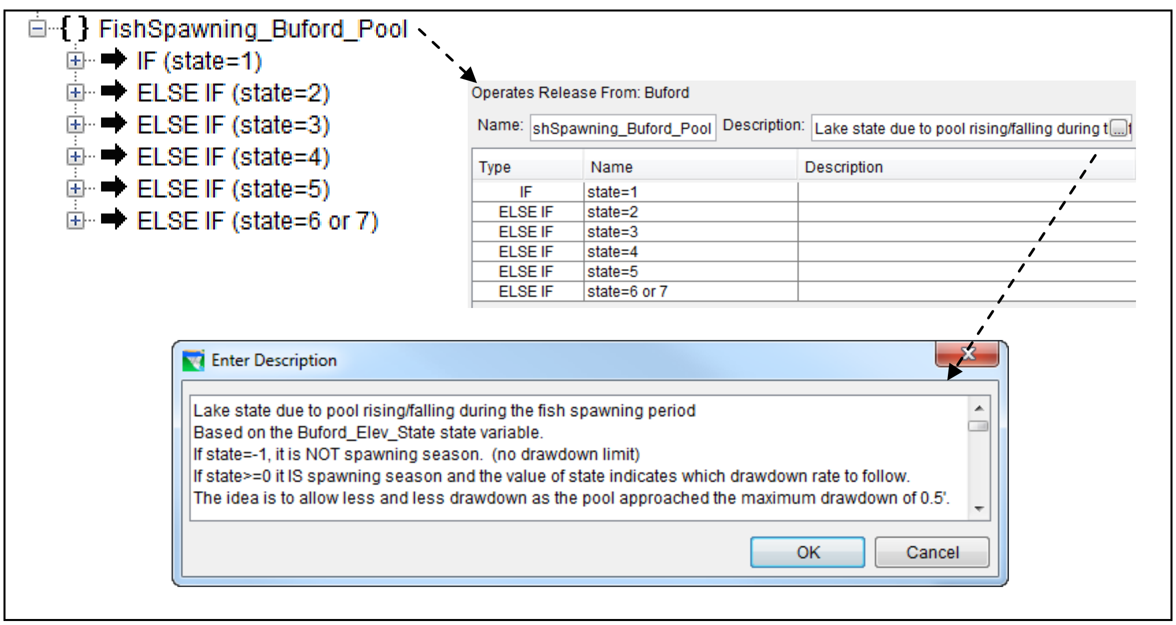


Figure K.10 Fish Spawning -- "Conditional Blocks" at Buford

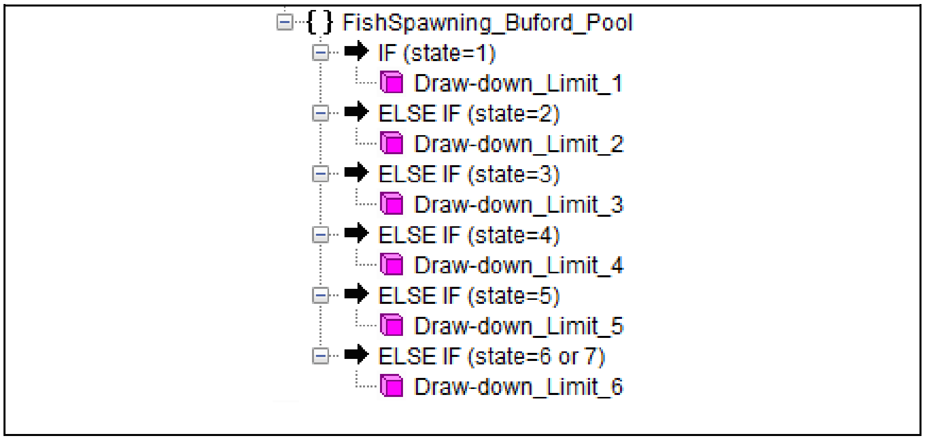


Figure K.11 Fish Spawning -- "IF-Blocks" and "Rules" at Buford

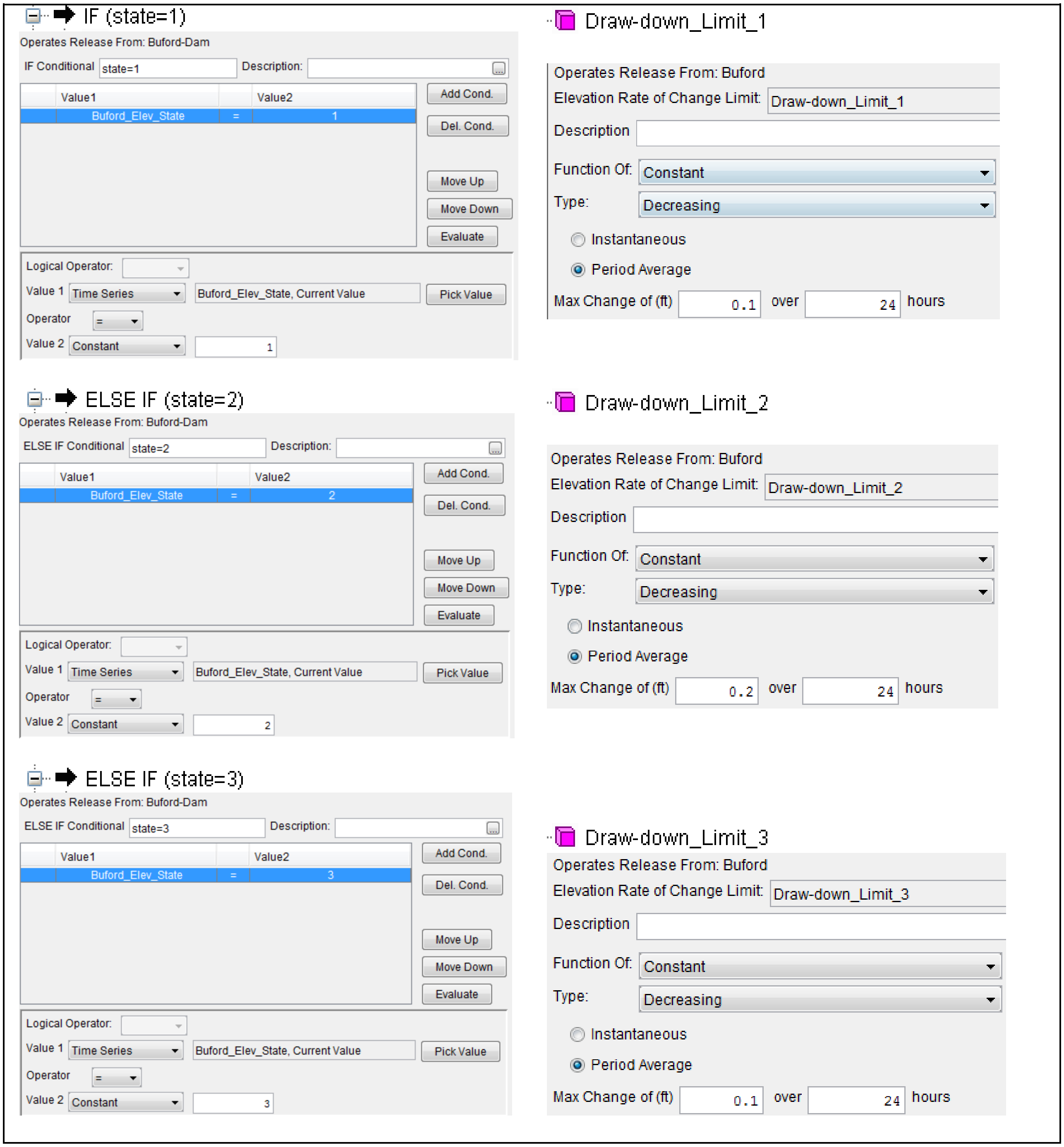


Figure K.12 Fish Spawning – Rules for "Buford_Elev_State" Values (Part 1 of 2) at Buford

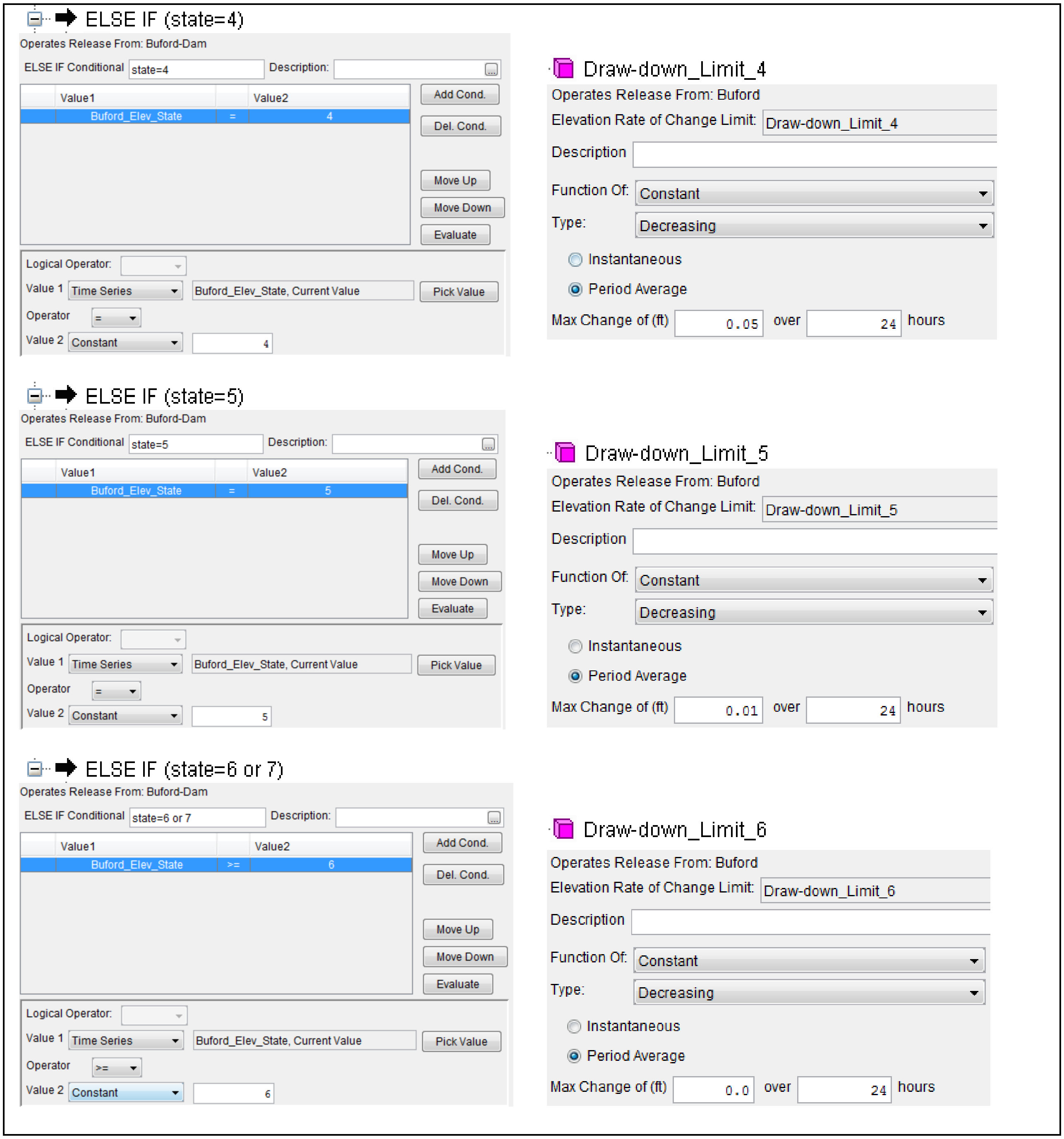


Figure K.13 Fish Spawning – Rules for "Buford_Elev_State" Values (Part 2 of 2) at Buford

B. Morgan Falls

The Flow-thru operation set was used in the NOAction alternative at Morgan Falls. The project contains four zones. The zones include Top of Dam, Maximum Pool, Conservation, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Morgan Falls is shown in Figure K.14.

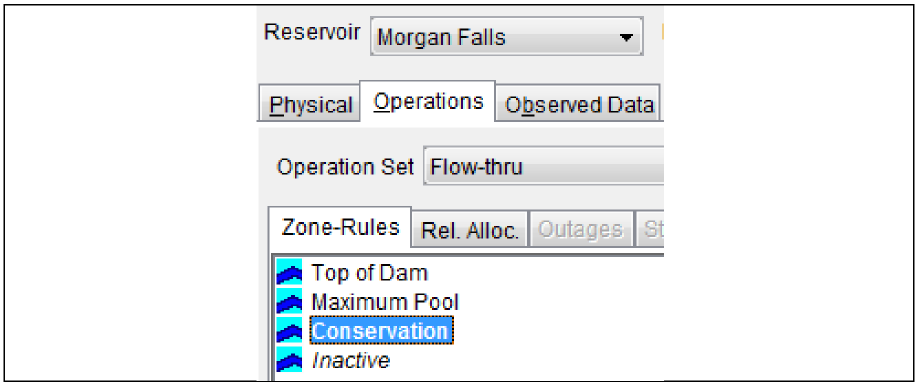


Figure K.14 Rule Set for Morgan Falls Flow-thru Operation Set

C. West Point

The NO-Action operation set was used in the NOAction alternative at West Point. The project contains seven zones. The zones include Top of Dam, Flood Control, Conservation, Zone 2, Zone 3, Zone 4, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the NO-Action operation set for West Point is shown in Figure K.15.

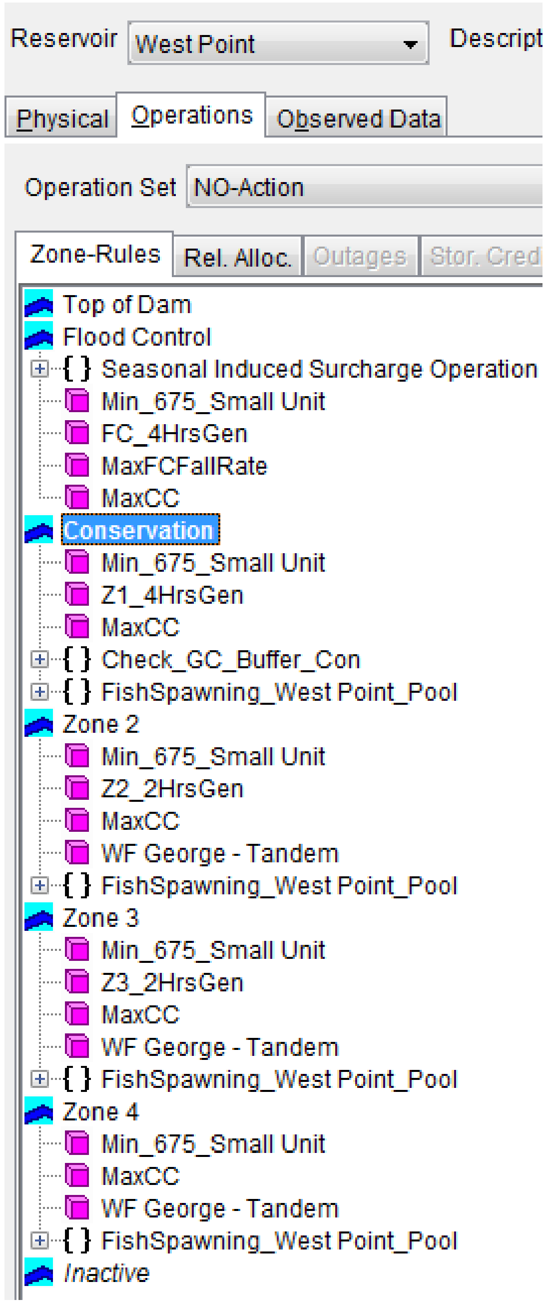


Figure K.15 Rule Set for West Point NO-Action Operation Set

1. *Min_675_Small Unit*

This rule (see Figure K.16) represents the flow release from the small unit, which is in use continuously throughout the year. Once the unit is on, the flow release is at approximately a constant of 675 cfs.

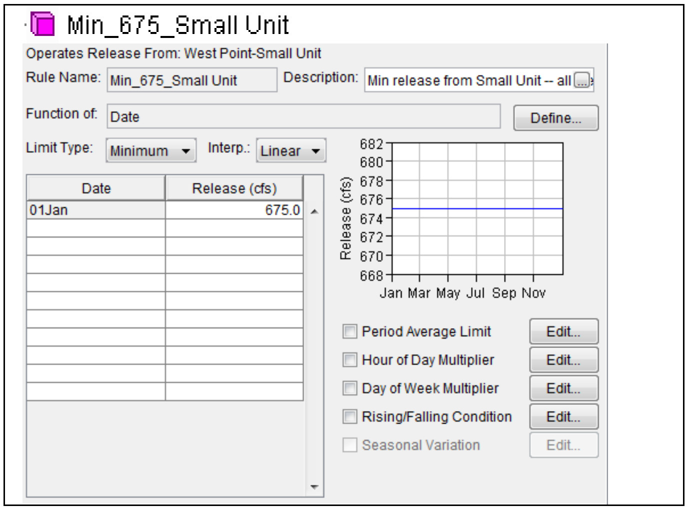


Figure K.16 *Min_675_Small Unit* at West Point

2. *MaxCC*

This rule (see Figure K.17) sets a maximum release from West Point Dam to the channel capacity (40,000 cfs) of the Chattahoochee River just downstream of the dam.

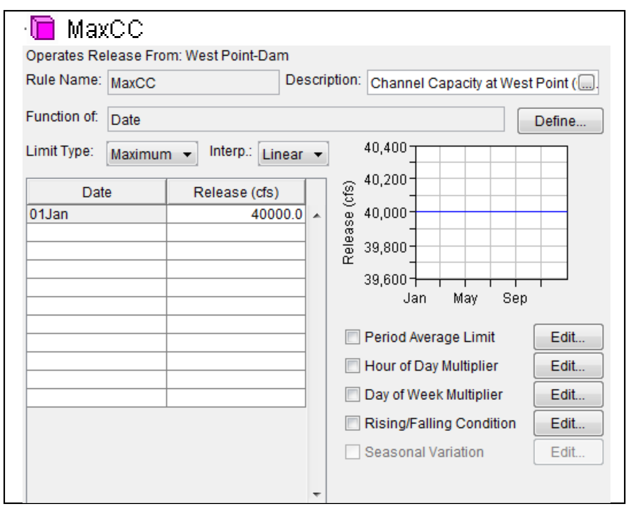


Figure K.17 *MaxCC* at West Point

3. MaxFCFallRate

This rule (see Figure K.18) sets the maximum rate of change for falling releases (when in the flood control pool) at 3,000 cfs per hour.

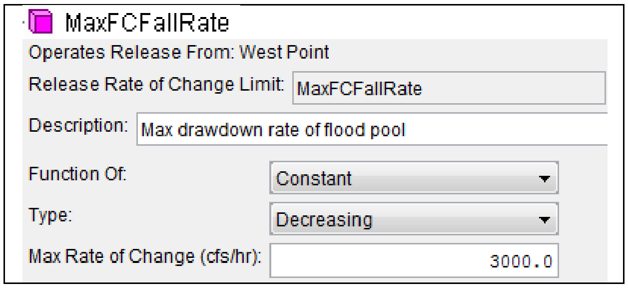


Figure K.18 *MaxFCFallRate* at West Point

4. WFGeorge-Tandem

This rule (see Figure K.19) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F George, and Lake Seminole to meet the Endangered Species Act (ESA) requirements on the Apalachicola River.

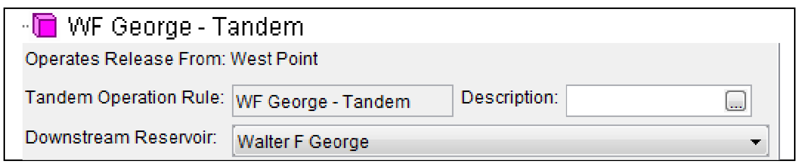


Figure K.19 *WFGeorge-Tandem* at West Point

5. { } Check_GC_Buffer_Con

This IF-Block (see Figure K.20) represents a modeling technique to minimize oscillations of the HEC-ResSim results. After much testing, it was found that the problem of the oscillations appeared when the pool elevation at West Point is adjacent to the West Point guide curve and when the pool elevation at Walter F George is at or above the Walter F George guide curve. A state variable (see Appendix H) named *WestPoint_GCBuffer*, was created to define a buffer zone around the West Point guide curve. The IF-Block set of conditional logic was created to define these two conditions, under which tandem operation is turned off. The release is then limited to the net inflow to West Point Lake up to the downstream channel capacity, which is 40,000 cfs. The operation rule associated with this flow release requirement is *MaxRel=Inflow* (see Figure K.20).

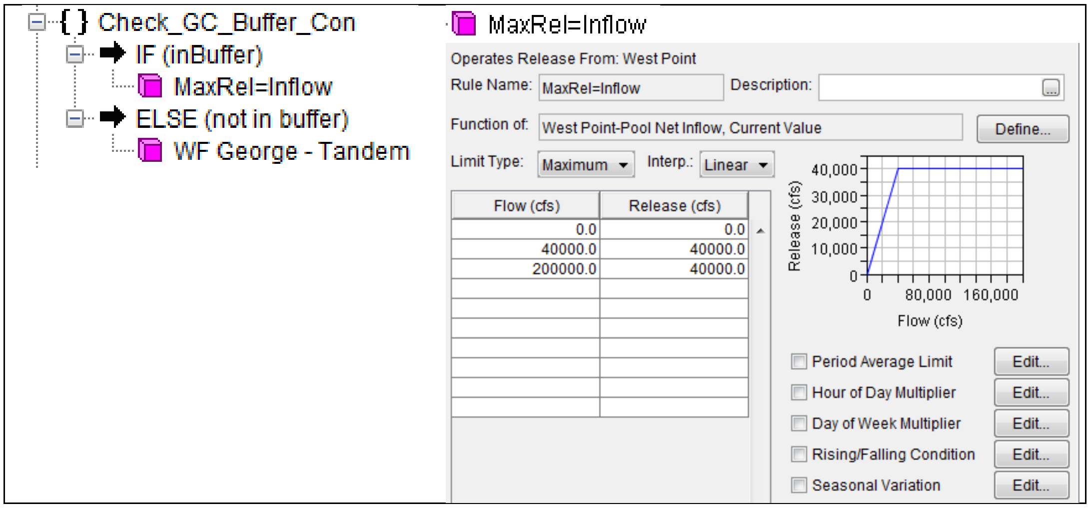


Figure K.20 *{ } Check_GC_Buffer_Con* at West Point

6. *Seasonal Induced Surcharge Operation*

This rule (see Figure K.21) 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 releases to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. An induced surcharge rule requires an induced surcharge schedule, which is a family of curves of spillway discharges and pool elevations for a range of reservoir inflows. In the daily model, the inflow at the previous time step is used. The induced surcharge schedule includes an induced surcharge envelope curve that represents the maximum reservoir levels that would be permitted at various rates of spillway discharge when operating under the induced surcharge plan. The induced surcharge rule also includes falling pool options. The *Time for Pool Decrease* (6 hours) 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* is the pool elevation below which the induced surcharge rule will no longer operate. This elevation is set to 635 ft in winter and 636.5 in summer. The *Release Options* assign the method for computing falling pool releases. For West Point Dam, the option of *Maintain Peak Gate Openings* is selected.

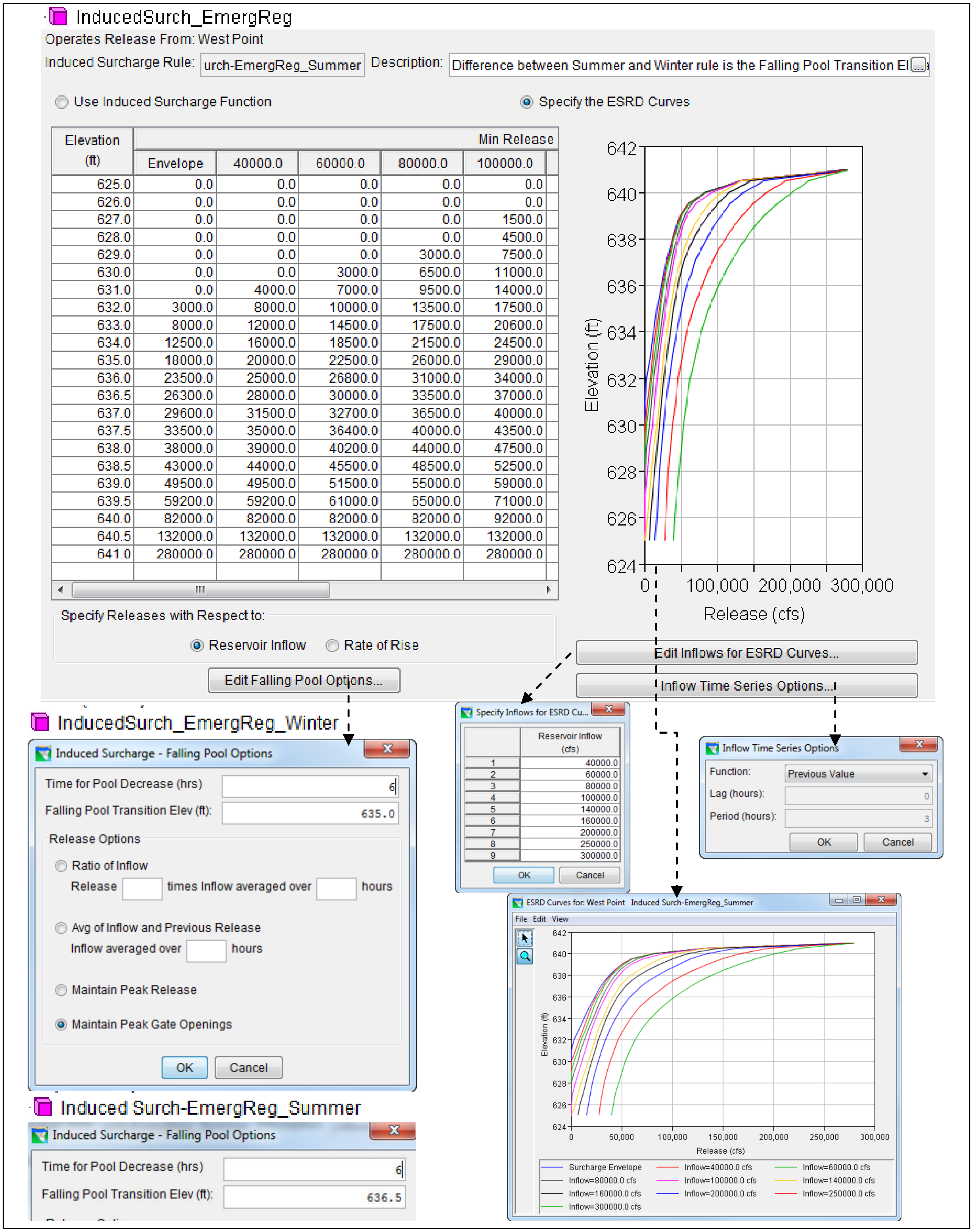


Figure K.21 ***InducedSurch_EmergReg*** **at West Point**

7. FC_4HrsGen, Z1_4HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure K.22) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor, which is a function of storage, and the requirement (4 or 2 hours of generation) varies by zones.

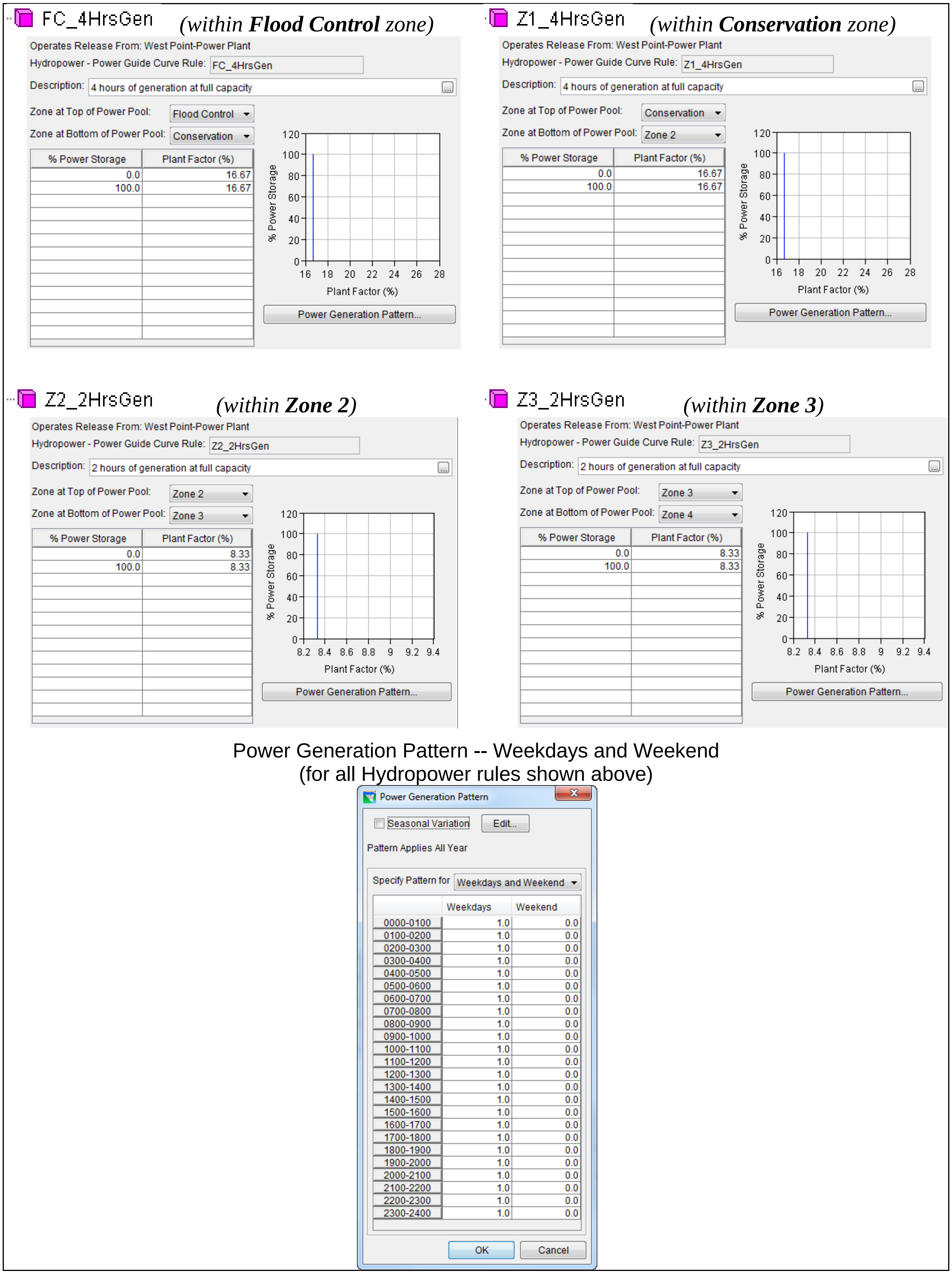


Figure K.22 Hydropower Rules at West Point

8. Fish Spawning_West Point

The IF-Blocks and rules (see Figure K.23 and Figure K.24) 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 April 1 through June 1 for West Point Lake, 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 G.

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: WestPoint_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
```

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

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 K.24). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure K.24):

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

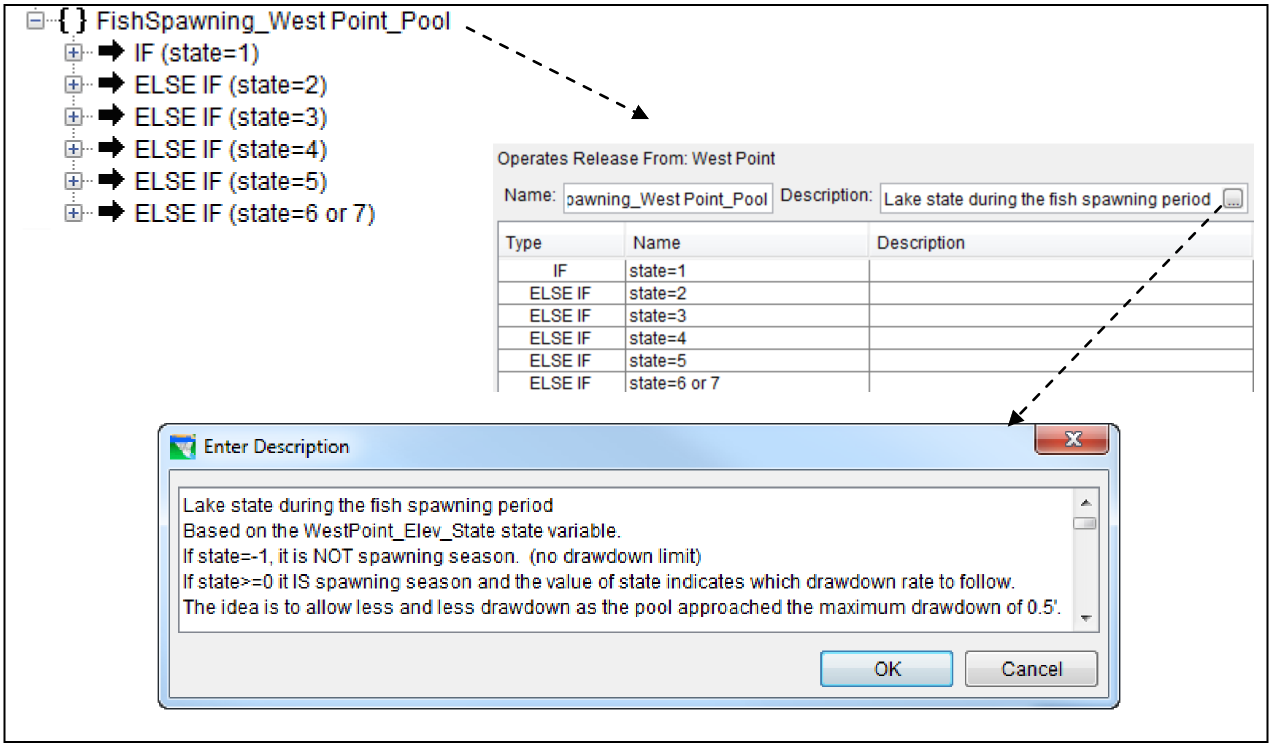


Figure K.23 Fish Spawning -- "Conditional Blocks" at West Point

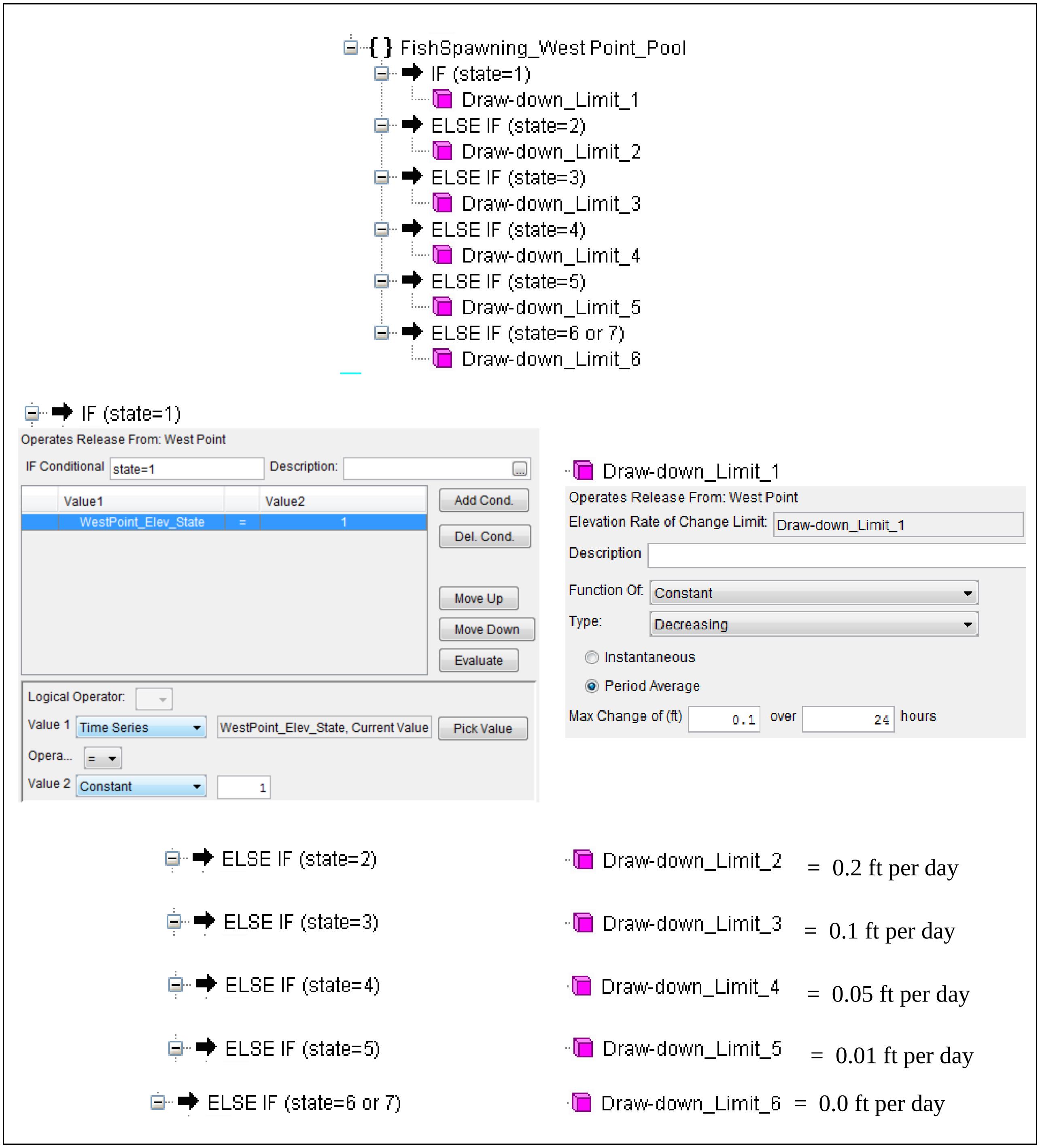


Figure K.24 Fish Spawning -- "IF-Blocks" and "Rules" and "WestPoint_Elev_State" Values at West Point

D. Bartletts Ferry

The Flow-thru operation set was used in the NOAction alternative at Bartletts Ferry. The project contains three zones. The zones include Top of Dam, Conservation, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Bartletts Ferry is shown in Figure K.25.

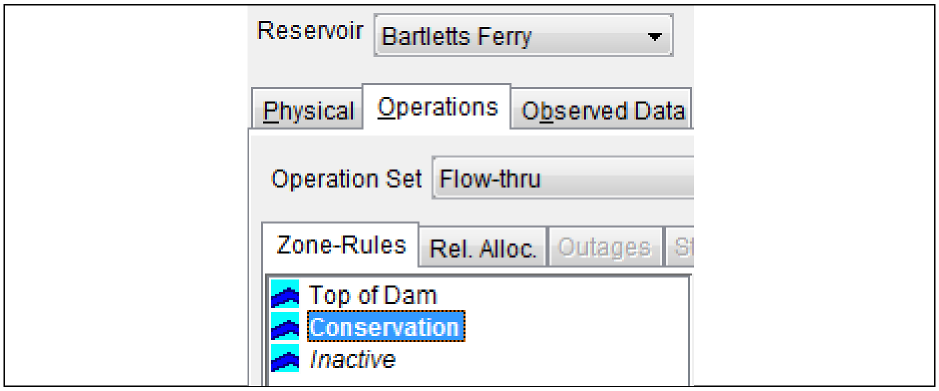


Figure K.25 Rule Set for Bartletts Ferry Flow-thru Operation Set

E. Goat Rock

The Flow-thru operation set was used in the NOAction alternative at Goat Rock. The project contains three zones. The zones include Top of Dam, Conservation, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Goat Rock is shown in Figure K.26.

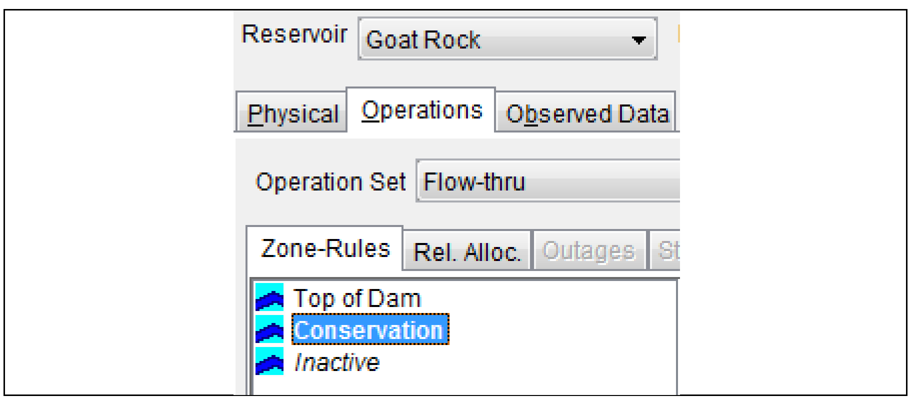


Figure K.26 Rule Set for Goat Rock Flow-thru Operation Set

F. Oliver

The Flow-thru operation set was used in the NOAction alternative at Oliver. The project contains three zones. The zones include Top of Dam, Conservation, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Oliver is shown in Figure K.27.

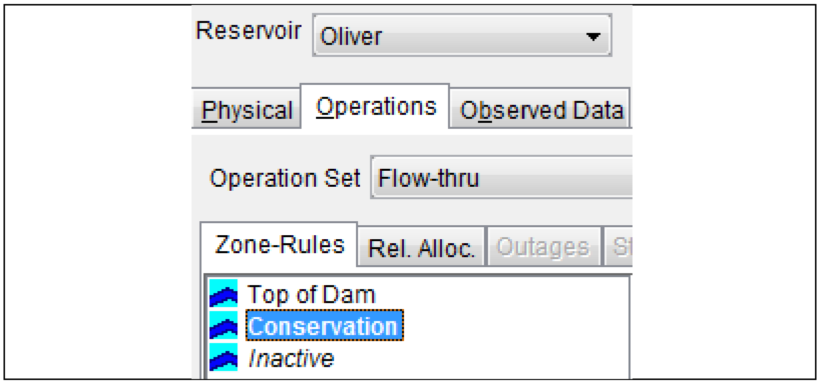


Figure K.27 Rule Set for Oliver Flow-thru Operation Set

G. North Highlands

The Flow-thru operation set was used in the NOAction alternative at North Highlands. The project contains three zones. The zones include Top of Dam, Conservation, and Inactive.. None of the zones contain rules. The rule set for the Flow-thru operation set for North Highlands is shown in Figure K.28.

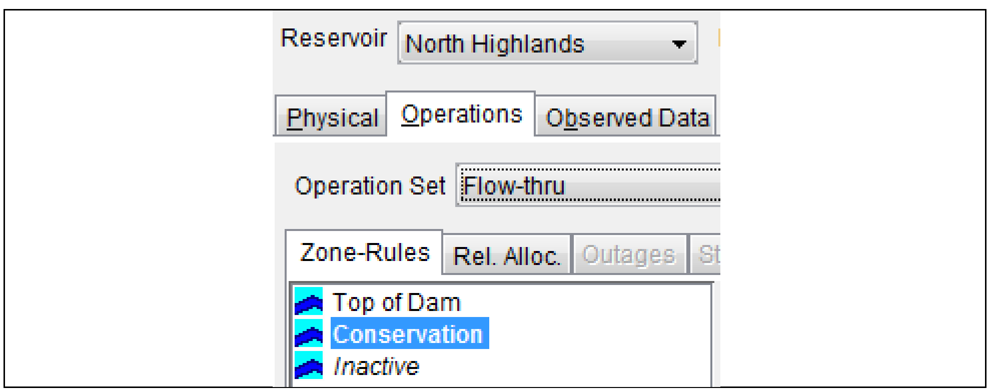


Figure K.28 Rule Set for North Highlands Flow-thru Operation Set

H. Walter F George

The NO-Action operation set was used in the NOAction alternative at Walter F George. The project contains eight zones. The zones include Top of Dam, Max Flood, Flood Control, Conservation, Zone 2, Zone 3, Zone 4, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the NO-Action operation set for Walter F George is shown in Figure K.29.

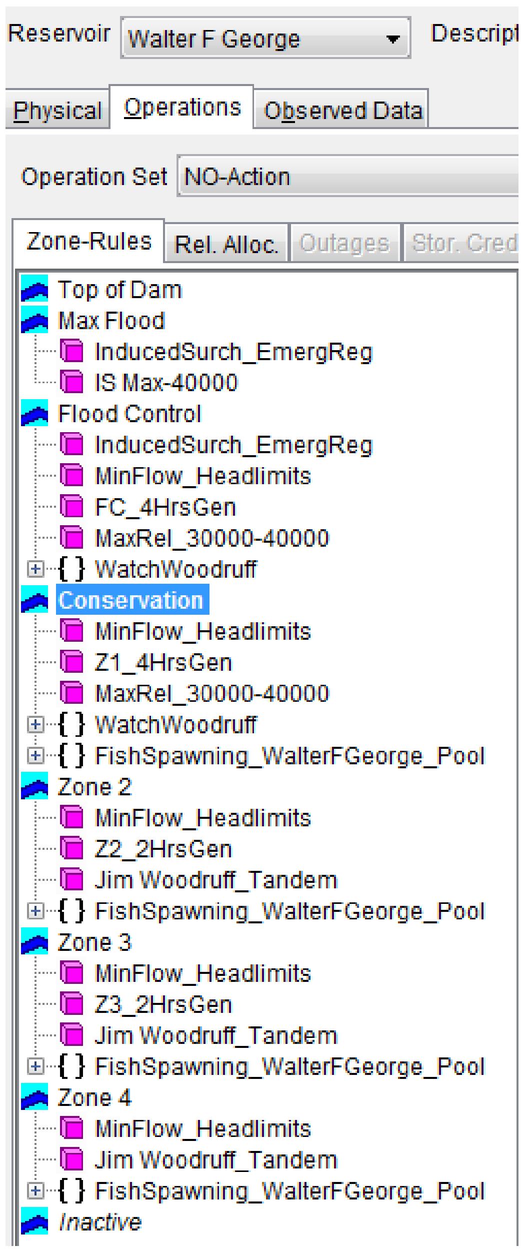


Figure K.29 Rule Set for Walter F George NO-Action Operation Set

1. IS Max-40000

This rule (see Figure K.30) sets a maximum release (40,000 cfs) from Walter F. George when induced surcharge operations are not in effect. It is essential to enter this maximum flow limit to guide releases back towards flood control operations after induced surcharge operations finish.

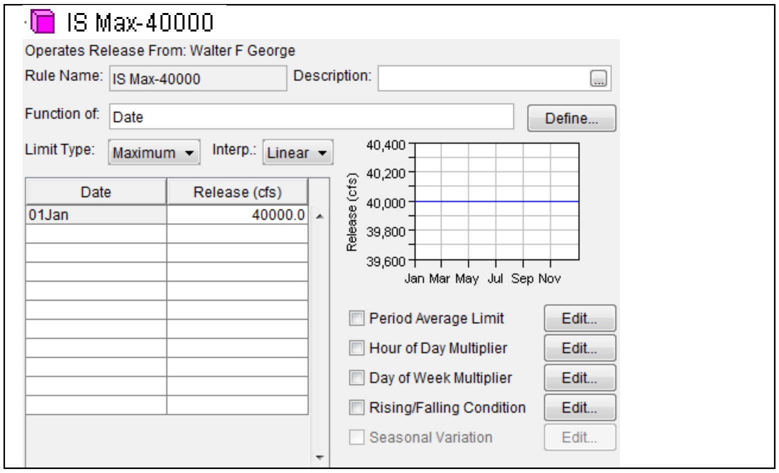


Figure K.30 *ISMax-40000* at Walter F George

2. MinFlow-Headlimits

This rule (see Figure K.31) represents the maximum head limit of 88 ft for Walter F. George Dam. A state variable, "WFGeorge_MinTailwater", is created to determine the minimum tailwater elevation at Walter F George based on the maximum head limit of 88 ft. Based on the pool elevation at the previous time step, the state variable script computes the minimum tailwater elevation for the current time step. In the ResSim model, the minimum tailwater elevation is converted to a discharge value based on the stage-discharge rating curve, and used as a minimum flow release from Walter F. George.

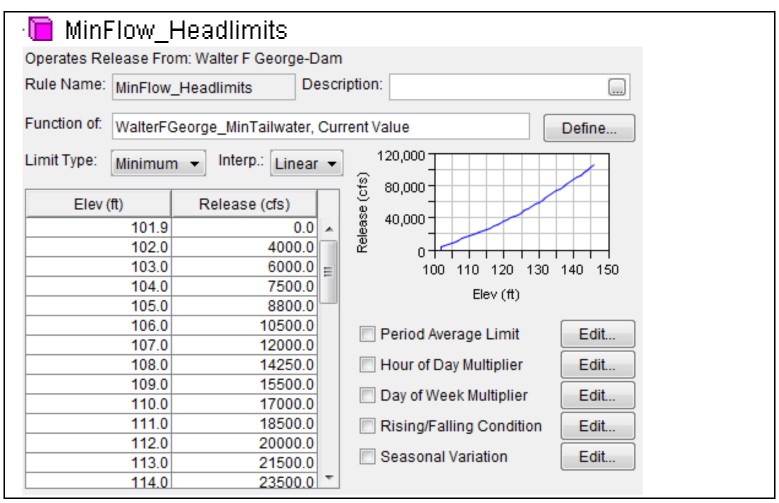


Figure K.31 *MinFlow-Headlimits* at Walter F George

3. MaxRel_30000-40000

This rule (see Figure K.32) sets a maximum release of 30,000 or 40,000 cfs, depending on pool elevations. From elevation 100.0 ft to 189.0 ft, the maximum release is 30,000 cfs. Above 189.0 ft, the maximum release is 40,000 cfs. The rule is used in both the flood control and conservation zones.

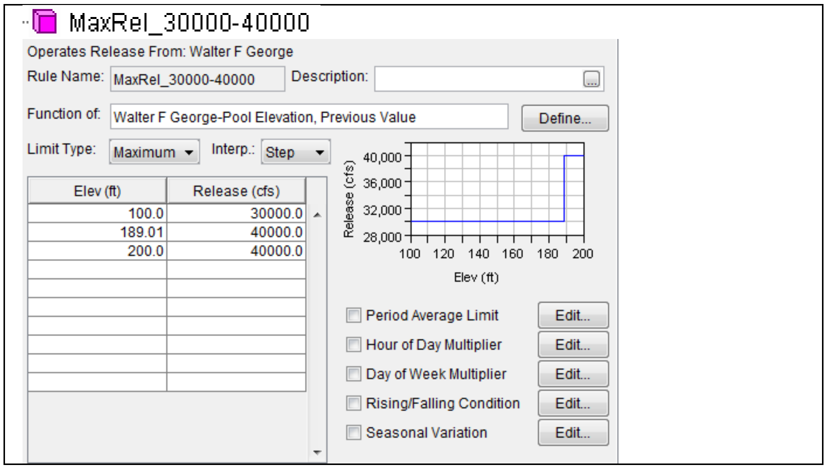


Figure K.32 *MaxRel_30000-40000* at Walter F George

4. Jim Woodruff-Tandem

This rule (see Figure K.33) represents a system operation to balance conservation storages across Lake Lanier, West Point, Walter F. George, and Lake Seminole to meet the Endangered Species Act (ESA) requirements on the Apalachicola River.

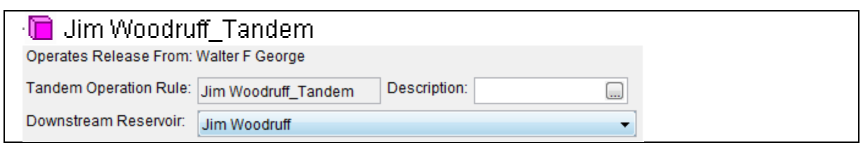


Figure K.33 *JimWoodruff_Tandem* at Walter F George

5. { } WatchWoodruff

This conditional logic (see Figure K.34) activates the tandem operation when the pool elevation at Lake Seminole is in Zone 1.

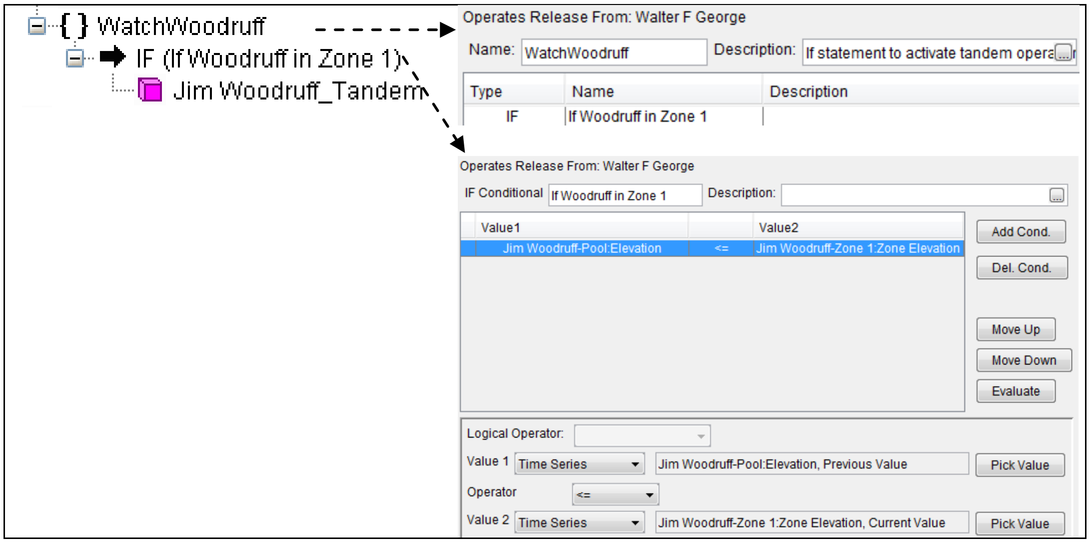


Figure K.34 *{ } WatchWoodruff* at Walter F George

6. InducedSurcharge_EmergReg

This rule (see Figure K.35) 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 releases to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. An induced surcharge rule requires an induced surcharge schedule, which is a family of curves of spillway discharges and pool elevations for a range of reservoir inflows. In the daily model, the inflow at the current time step is used. The induced surcharge schedule also includes an induced surcharge envelope curve that represents the maximum reservoir levels that would be permitted at various rates of spillway discharge when operating under the induced surcharge plan. The induced surcharge rule also includes falling pool options. The *Time for Pool Decrease* 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* is the pool elevation below which the induced surcharge rule will no longer operate. The *Release Options* assign the method for computing falling pool releases. For Walter F. George Dam, the option of *Maintain Peak Release* is selected.

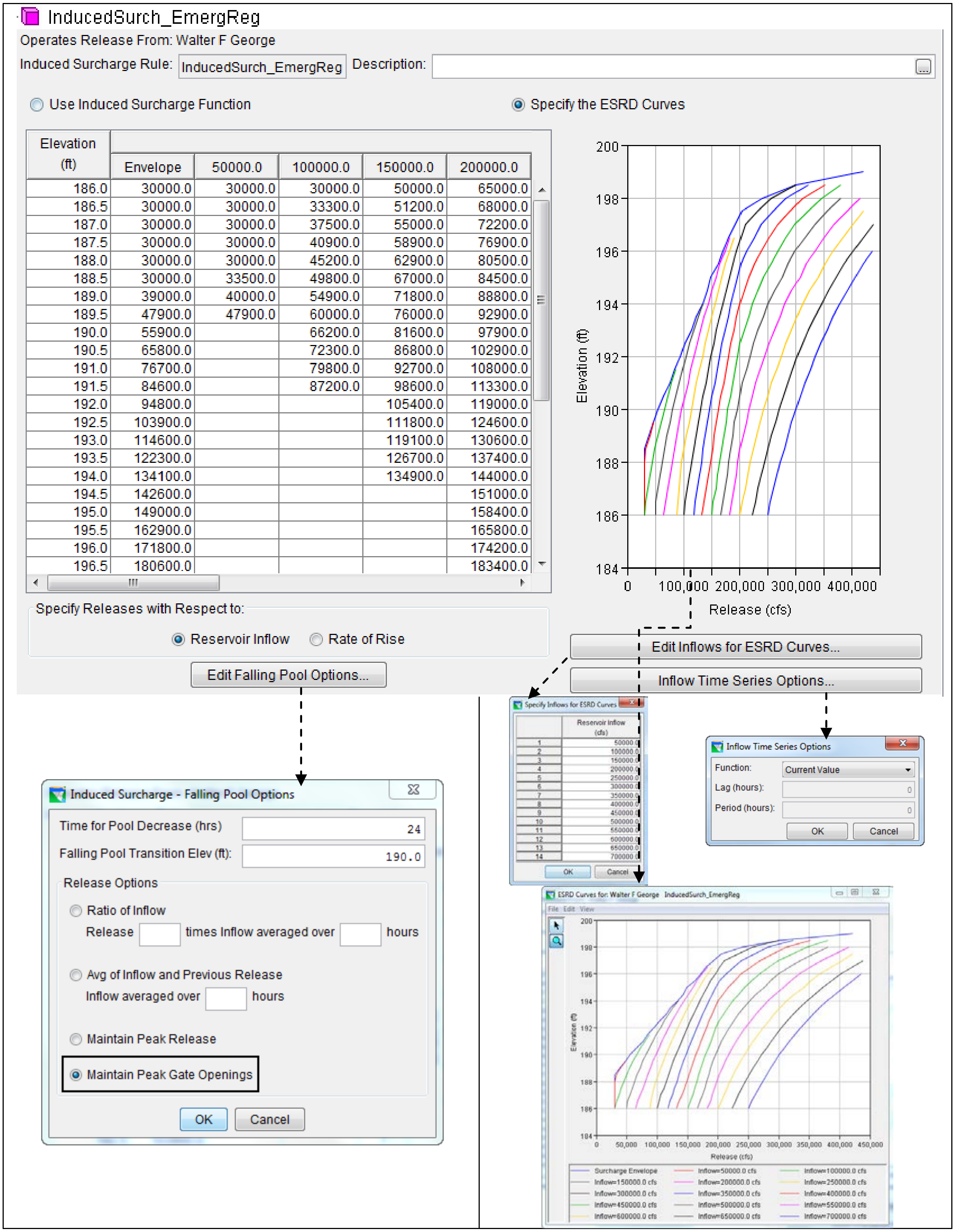


Figure K.35 ***InducedSurch_EmergReg*** **at Walter F George**

7. FC_4HrsGen, Z1_4HrsGen, Z2_2HrsGen, and Z3_2HrsGen

These are hydropower rules (see Figure K.36) that reflect Power Guide Curve operation where the power requirement is defined as a Plant Factor, which is a function of storage and the requirement (4 or 2 hours of generation) varies by zones.

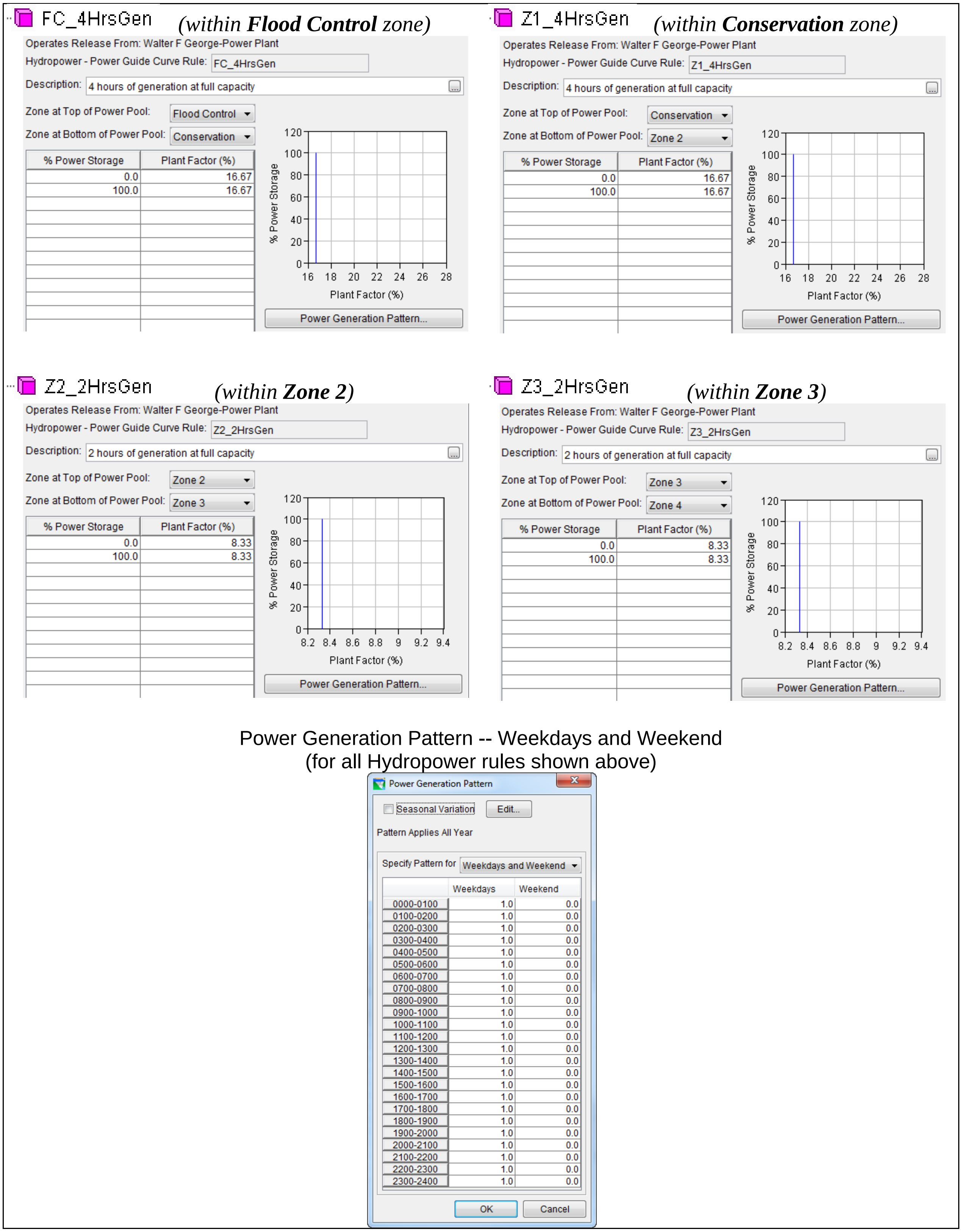


Figure K.36 Hydropower Rules at Walter F George

8. Fish Spawning_Walter F George

The IF-Blocks and rules (see Figure K.37 through Figure K.38) 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 March 15 through May 15 for Lake Eufaula, 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 H.

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 in as follows:

```
# State variable: WalterFGeorge_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
```

The state variable (“WalterFGeorge_Elev_State”) script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is described in Appendix G.

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 K.37 and Figure K.38). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied (Figure K.37 and Figure K.38):

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

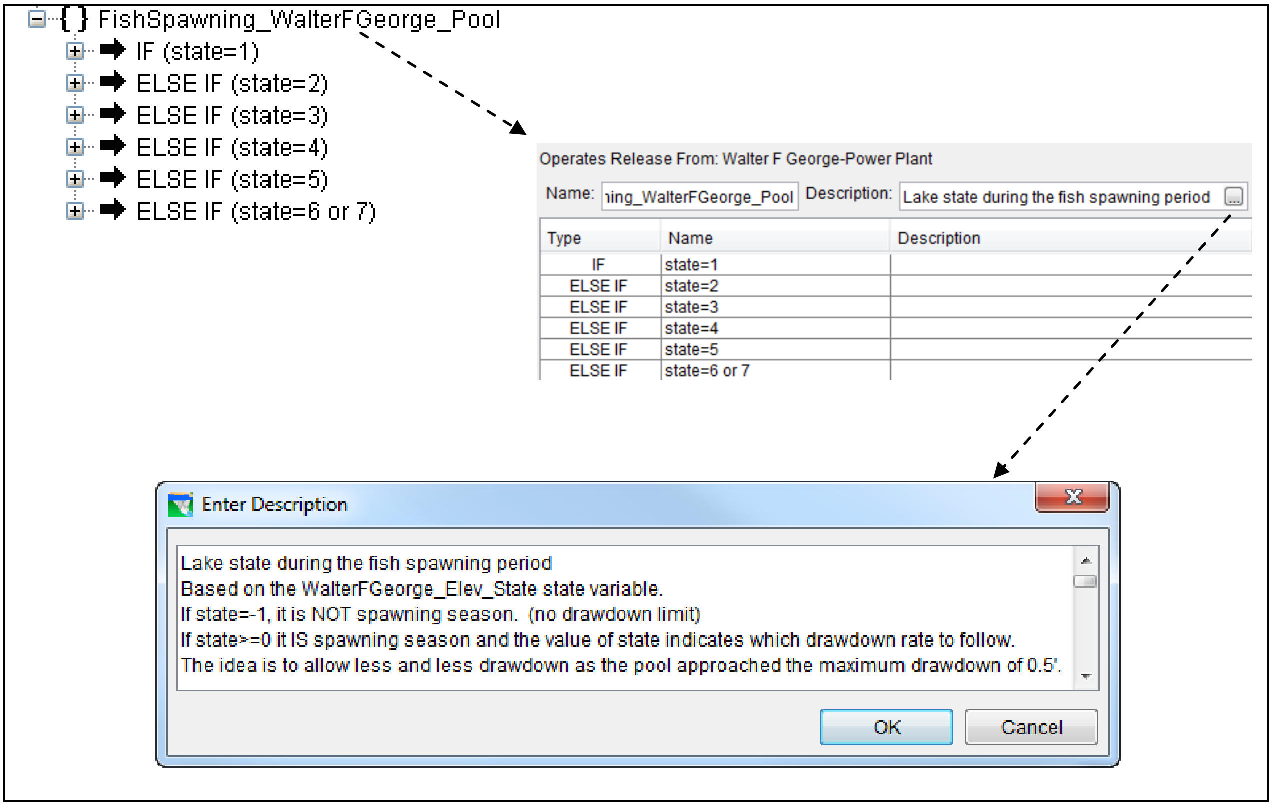


Figure K.37 Fish Spawning -- "Conditional Blocks" at Walter F George

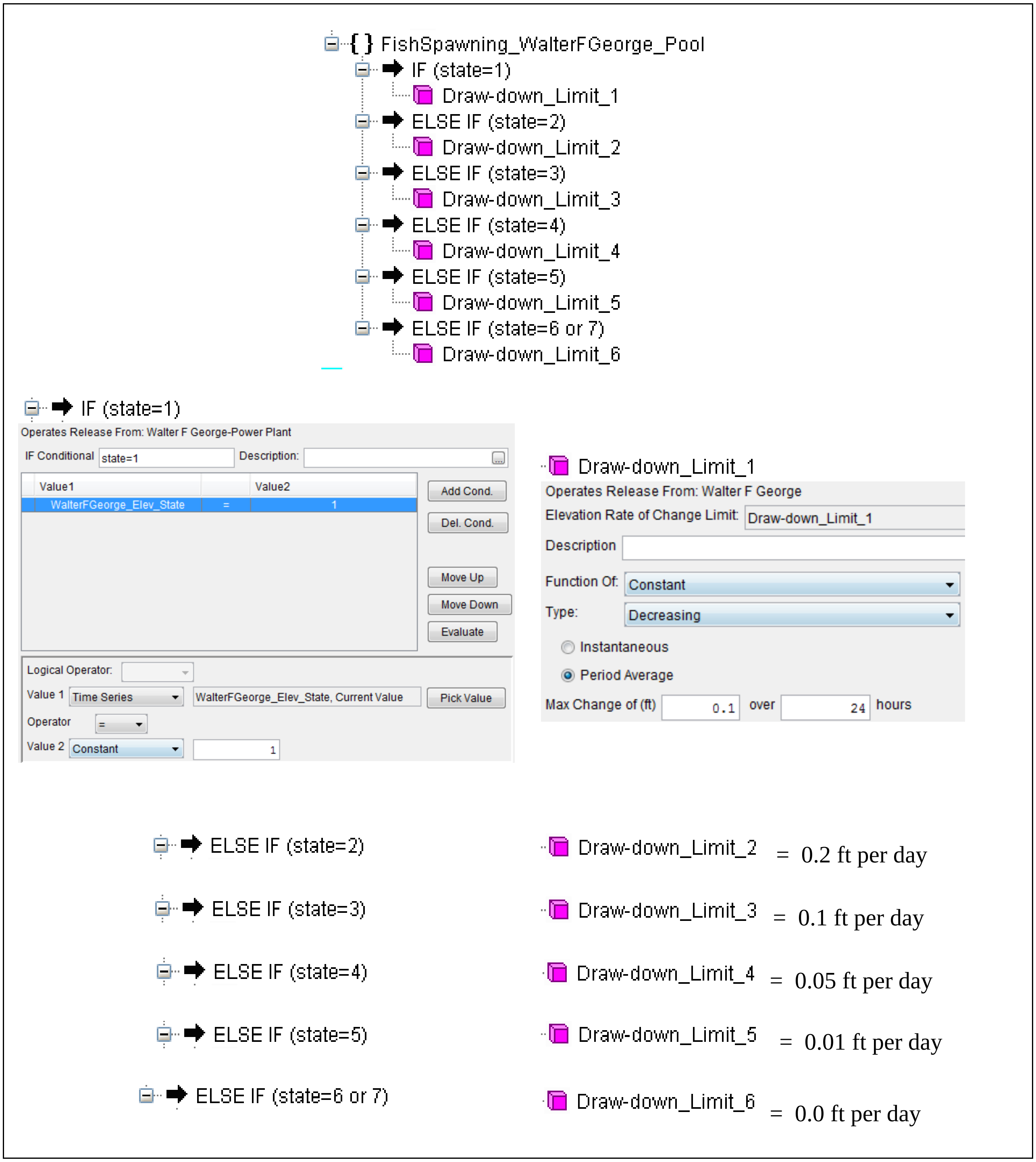


Figure K.38 Fish Spawning -- "IF-Blocks" and "Rules" and "WalterFGeorge_Elev_State" Values at Walter F George

I. George Andrews

The Flow-thru operation set was used in the NOAction alternative at George Andrews. The project contains four zones. The zones include Flood Control, Conservation, operating Inactive, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for George Andrews is shown in Figure K.39.

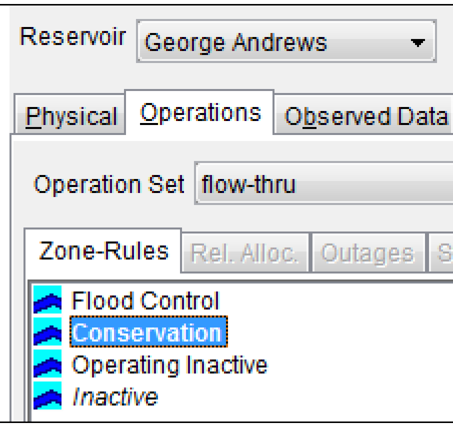


Figure K.39 Rule Set for George Andrews Flow-thru Operation Set

J. Jim woodruff

The NO-Action operation set was used in the NOAction alternative at Jim Woodruff. The project contains nine zones. The zones include Top of Dam, Flood Control, Conservation, Zone 1, Zone 2, Zone 3, Zone 4, Operating Inactive, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the NO-Action operation set for Jim Woodruff is shown in Figure K.40.

Figure K.40 Rule Set for Jim Woodruff NO-Action Operation Set

1. *MinRel_Headlimit*

This rule (see Figure K.41) represents the physical operation constraint of the maximum head limit at Jim Woodruff Dam. A head limit curve, which was provided by the Mobile District, defines the minimum tailwater elevation necessary to adequately limit the head difference for a given reservoir pool elevation. A state variable, “Woodruff_MinTailwater”, is created to determine the minimum tailwater elevation based on the head limit curve. Using the pool elevation at the previous time step, the state variable script computes the minimum tailwater elevation for the current time step. In the ResSim model, the minimum tailwater elevation is converted to a discharge value based on the tailwater stage-discharge rating curve at the downstream USGS Chattahoochee gage and is used as a minimum release from Jim Woodruff. This head limit rule is placed at the top of each zone indicating the highest rule priority for each zone.

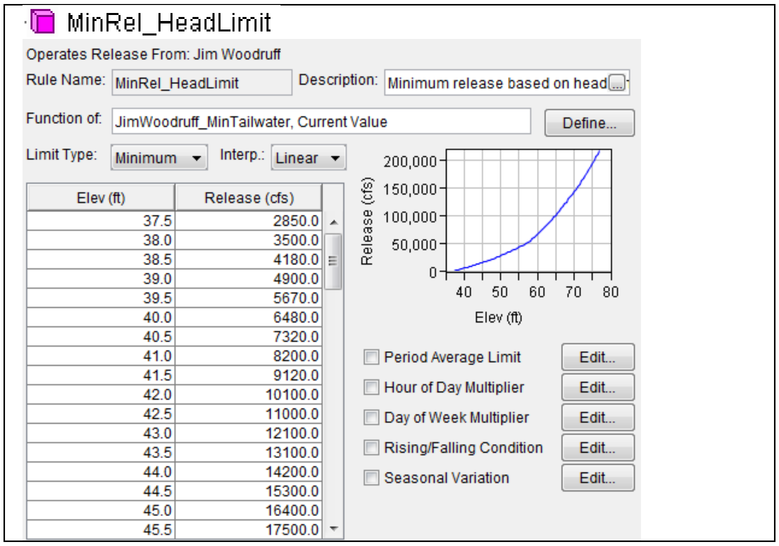


Figure K.41 *MinRel_Headlimit* at Jim Woodruff

2. *{ } Flow Target*

This conditional logic (see Figure K.42) describes the complex operational requirements to represent a modification of the current Interim Operations Plan at Jim Woodruff Dam. The Revised Interim Operations Plan (RIOP) establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table K.04. Details of the proposed action are described in a separate document, entitled “Description of Proposed Action, Modification to the Interim Operations Plan at Jim Woodruff Dam, dated April 2008 (file name: ProposedActionDescription-Modification_to_IOP.pdf)”, hereafter referred to as RIOP2012.

Table K.04 Proposed Action Modified IOP Releases from Jim Woodruff Dam (Source: RIOP2012)

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage[1]
March – May (Spawning season)	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June – November (Non-spawning season)	Zones 1, 2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December – February (Winter)	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4 Or Drought Ops	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	>= 4,500[2]	Up to 100% BI > 4,500

[1] Consistent with safety requirements, flood control purposes, and equipment capabilities.
[2] Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/day drop.

To implement the proposed actions in RIOP2012, a number of state variables are created to determine basin inflow (BI), composite storage (CS), basin inflow fall rate, and seasons. Based on the active composite storage and composite action zones, the state of the composite storage is defined as follows:

Composite Storage State	Definition
0	Above conservation zone (flood pool)
1	Between top of conservation zone and top of zone 2 (within Zone 1)

2	Within Zone 2
3	Within Zone 3
4	Within Zone 4
5	Within drought zone

In addition, a state variable, called "DO4-1," is created to track the drought conditions. The drought plan is "triggered" when composite storage falls below the bottom of Zone 3 into Zone 4.The drought plan provisions remain in place until conditions improve such that the composite storage reaches a level above the top of Zone 2 (i.e., within Zone 1). The drought plan is in effect if it holds a value of 1 (i.e., "true"). There is another state variable, named "*EDO_Flow*", to track if Jim Woodruff needs to release an exceptional drought operation (EDO) minimum flow. For details of all these state variables, refer to Appendix H.

Figure K.43 shows that there are three IF-Blocks under the conditional *Flow Target* logic. It defines if the current condition is in Drought Operations, if the composite storage is in Zone 4 or Zone 5, or if the composite storage is above Zone 4.

3. MinRel_4550 and MinRel_5050

These two rules (see Figure K.44) reflect that when the state variable, "EDO_Flow", holds a value of 1, Jim Woodruff releases a minimum of 4,550 cfs under an exceptional drought operation. Otherwise, the minimum release is 5,050 cfs. Also, when the pool is in composite storage Zone 4 or above the MinRel-5050 is active. It should be noted that the required minimum flow values from RIOP2012 are increased by 50 cfs in the model to ensure a "factor of safety".

4. { } Seasons

RIOP2012 (Table K.04) specifies the minimum release from Jim Woodruff as a function of seasons, composite storage, and basin inflow. It divides a year into three seasons: (a) spawning season -- March through May; (b) non spawning season -- June through November; and, (c) winter -- December through February (see Figure K.46).

a. IF (Spawning (Mar – May))

During the fish spawning season, the minimum flow releases are different when the active composite storage is within Zones 1 and 2 or within Zone 3. Under each condition, the minimum release is dependent on the basin inflows. For example, within Zones 1 and 2, the following release schedule is defined:

Basin Inflow (cfs)	Minimum Release (cfs)
>= 34,000	25,000
>=16,000 and < 34,000	16,000 +50% of BI
>=5,000 and < 16,000	BI
< 5,000	5,050

To specify these minimum flow releases, several minimum flow rules are used, including: *MinRel_25000*, *MinRel_0.5xBI7D_16000*, *MinRel_0.5xBI7D_11000*, *MinRel_BI*, and *MinRel_5050* (see Figure K.46).

b. ELSE IF (Non Spawning (Jun – Nov))

During the non-spawning season (June through November), the minimum flow releases are dependent on the basin inflow only. The release schedule is defined as follows:

Basin Inflow (cfs)	Minimum Release (cfs)
>= 22,000	16,000
>=10,000 and < 22,000	10,000 +50% of BI
>=5,000 and < 10,000	BI
<5,000	5,050

To specify these minimum flow releases, four minimum flow rules are used, including *MinRel_16000, MinRel_0.5xBI7D_10000, MinRel_BI,* and *MinRel_5050* (see Figure K.47).

c. ELSE (Winter (Dec – Feb))

In winter months (December through February), the minimum flow release is 5,050 cfs, regardless of the composite storage and basin inflow (see Figure K.47).

5. { } Ramp_ Rate_DO4-1

This conditional logic (see Figure K.47) describes maximum fall rates (or down-ramping rates), measured at the Chattahoochee gage, and describes drought contingency operations.

6. { } Hold_RR

This conditional logic (see Figure K.47) is used to maintain the RIOP-Falling Ramp Rate rule when Drought operation first occurs until the target minimum flow is reached, at which point the RIOP-Falling Ramp Rate is suspended. The target minimum flow is 5050 cfs during Drought Operation (DO) and 4550 cfs during Exceptional Drought Operation (EDO).

7. BI-Falling Ramp Rate

This rule (see Figure K.47) sets the fall rates under the drought operation. According to RIOP2012, when the drought operation is in effect, the fall rate matches the fall rate of the basin inflow, which is calculated in the state variable, "BIFallRate". Also, when BI is rising for flow less than 22,000 cfs the falling ramp rate is limited to 2 ft fall rate.

8. RIOP-Falling Ramp Rate:

RIOP2012 specifies the maximum fall rates in river stages when the release is less than or equal to 30,000 cfs. Using the discharge-stage rating curve at the downstream Chattahoochee gage, the fall rates in stage are converted to fall rates in discharge. Therefore, a rate of change (decreasing in discharge) rule is established (see Figure K.47).

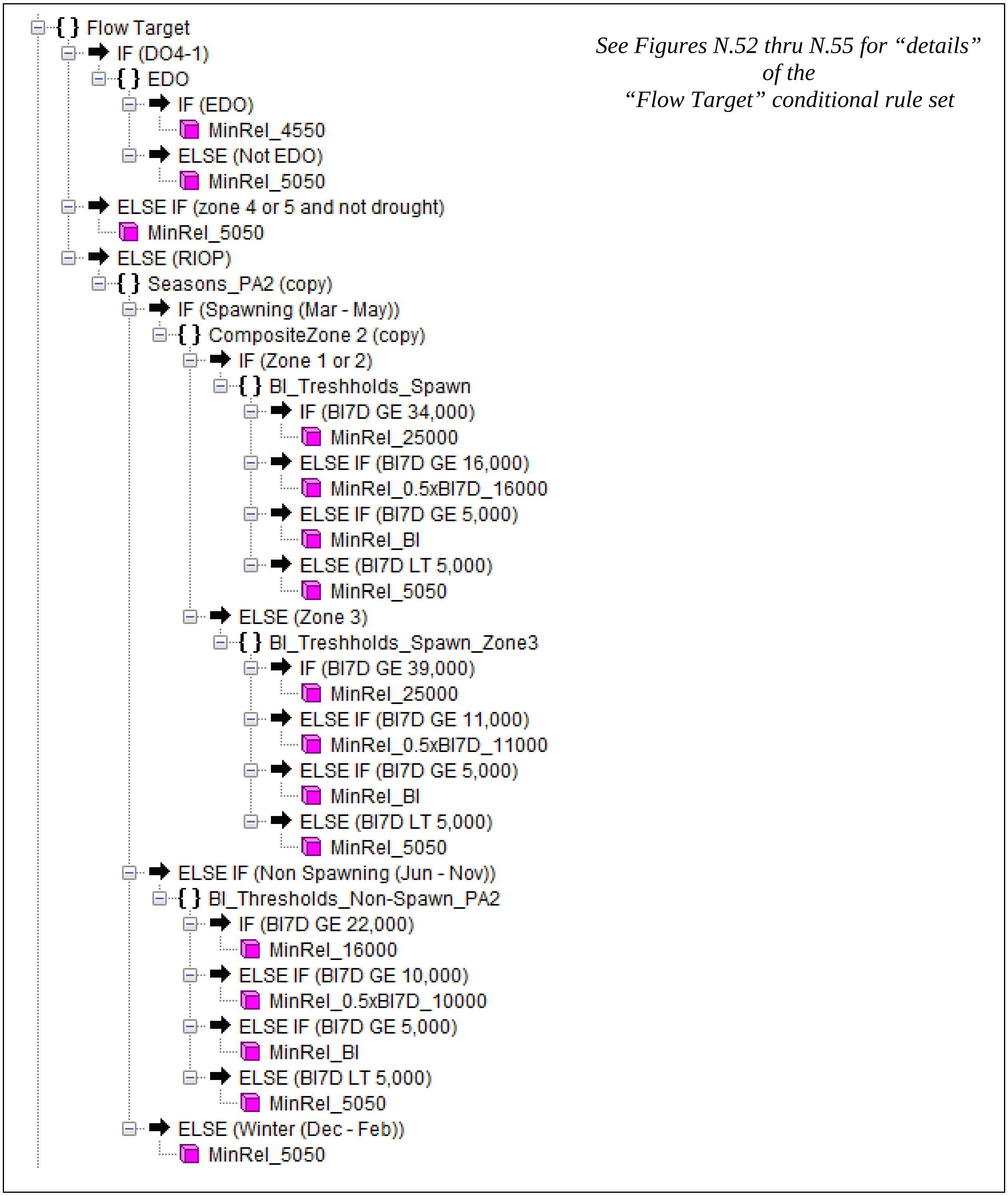


Figure K.42 NO-Action OpSet -- ESA Conditional Rule Set at Jim Woodruff

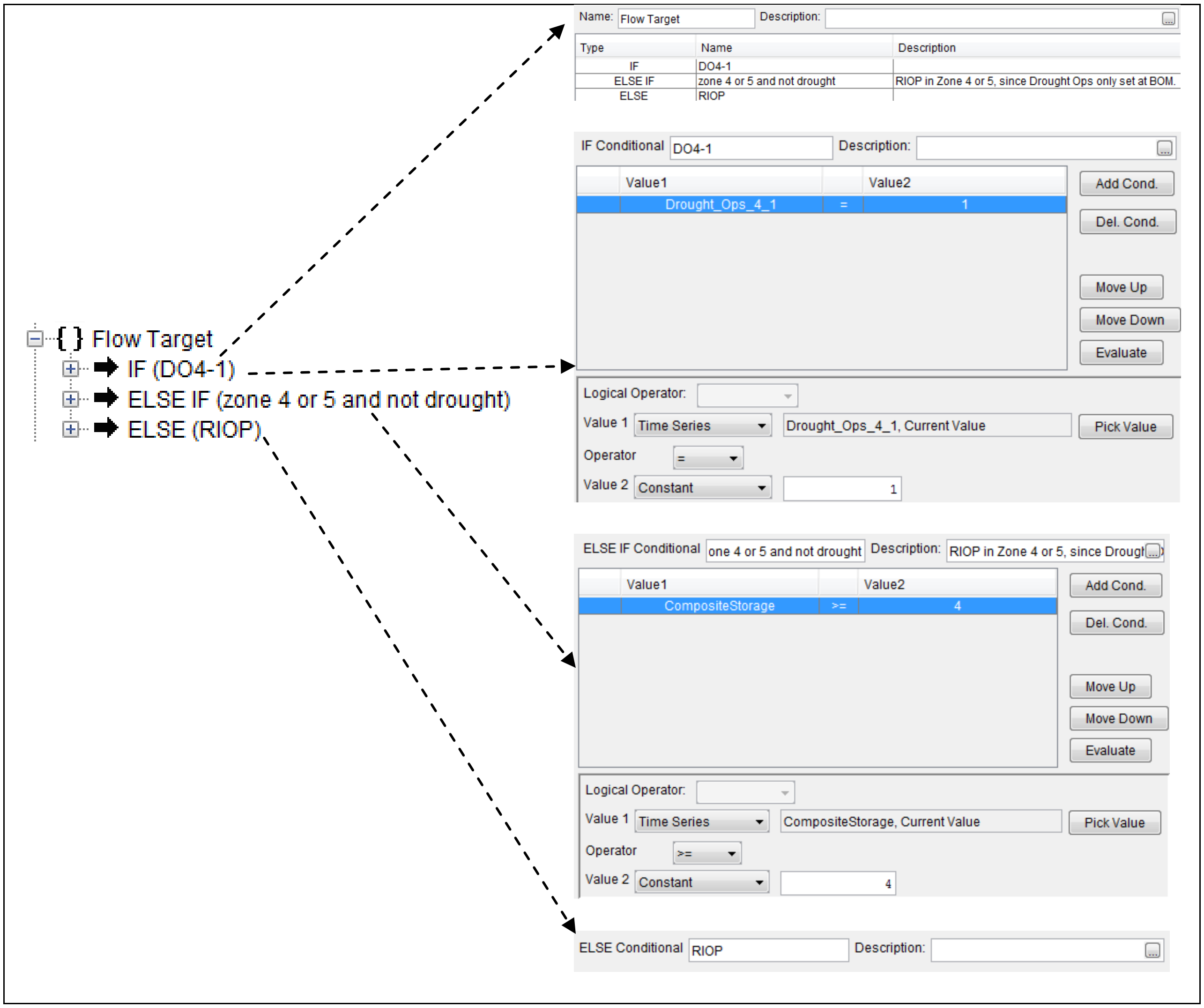


Figure K.43 ESA (Part 1 of 4): Overview of " IF (DO4-1) - Else IF (Zone 4 or 5 and not drought) -Else (RIOP)"

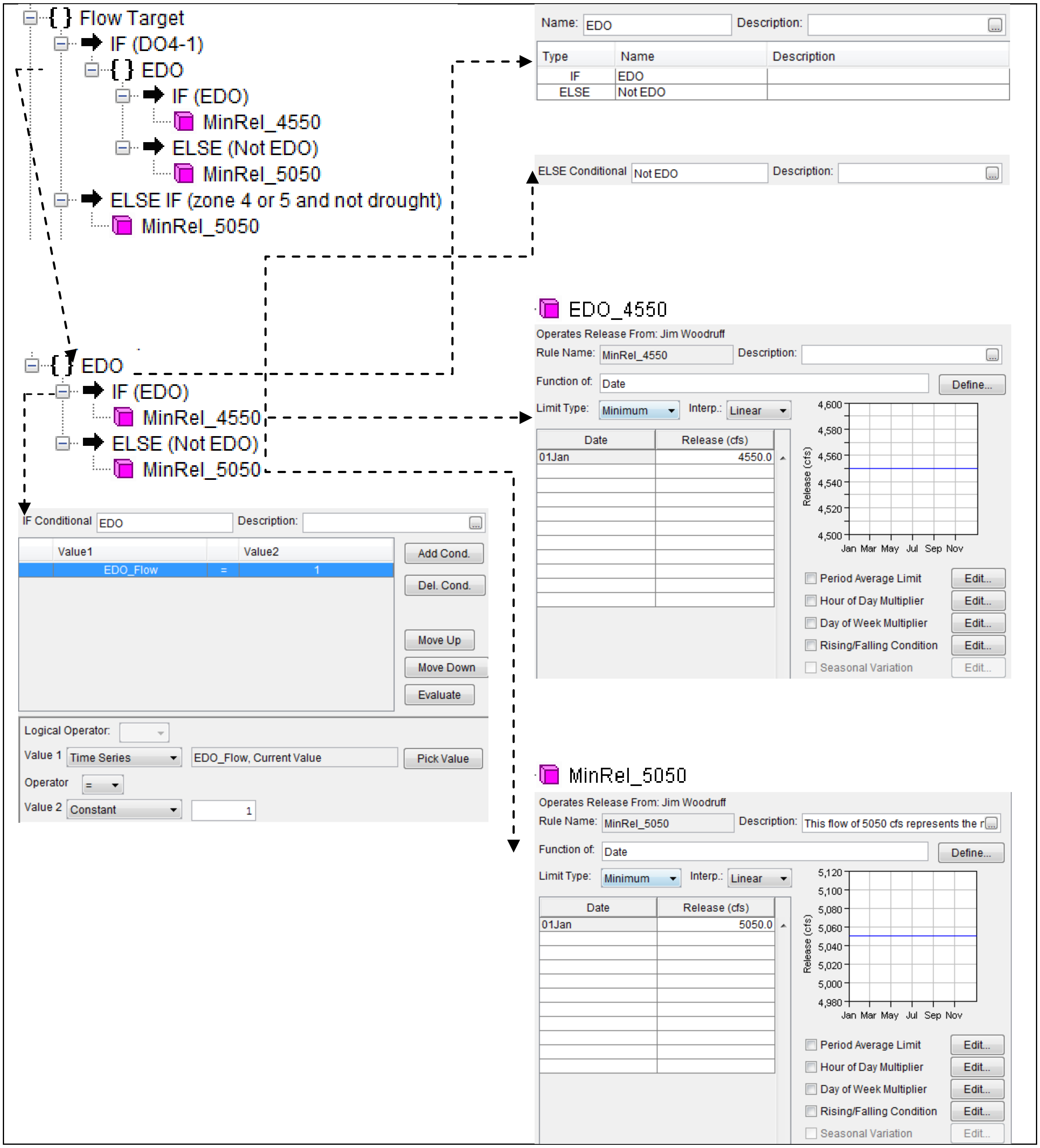


Figure K.44 ESA (Part 2 of 4): Drought Operations ,Checking for "EDO" , "MinRel_4550"and Not EDO, "MinRel_5050"

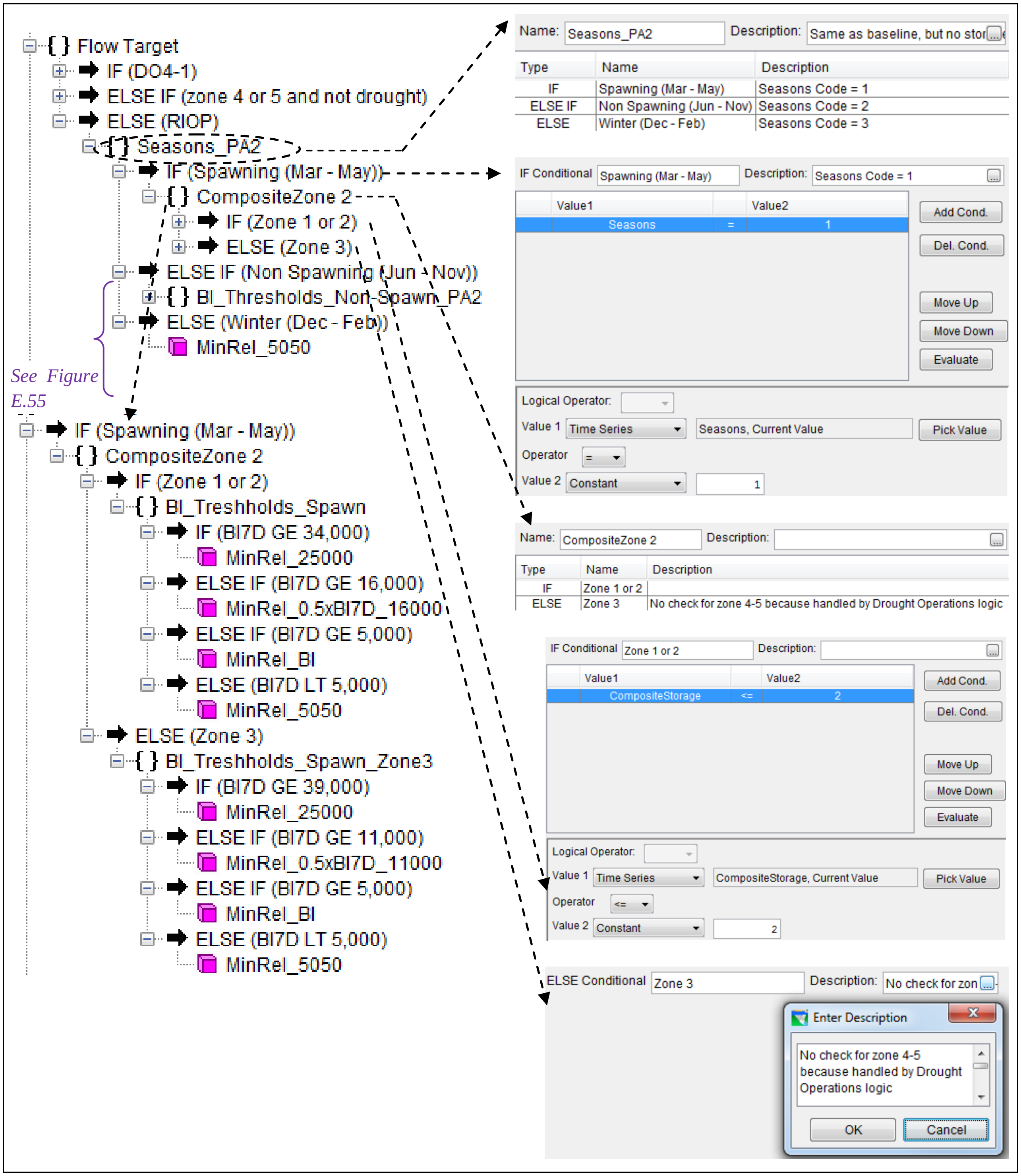


Figure K.45 ESA (Part 3 of 4): Seasons – Part 1 of 2 – "Overview" and check for "Spawning (Mar-May)"

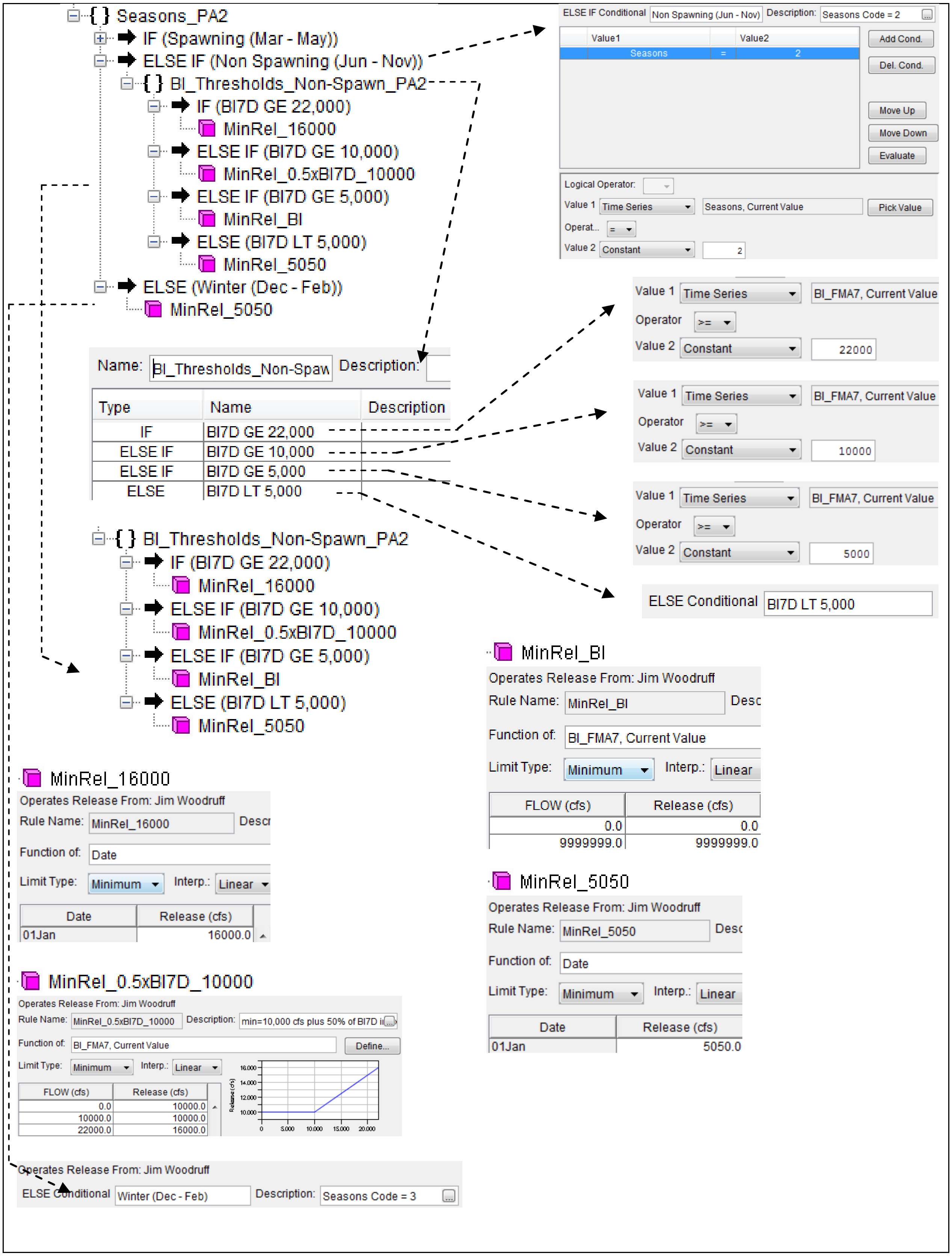


Figure K.46 ESA *(Part 4 of 4)*: Seasons – *Part 2 of 2* – Check for "Non Spawning (Jun-Nov)"

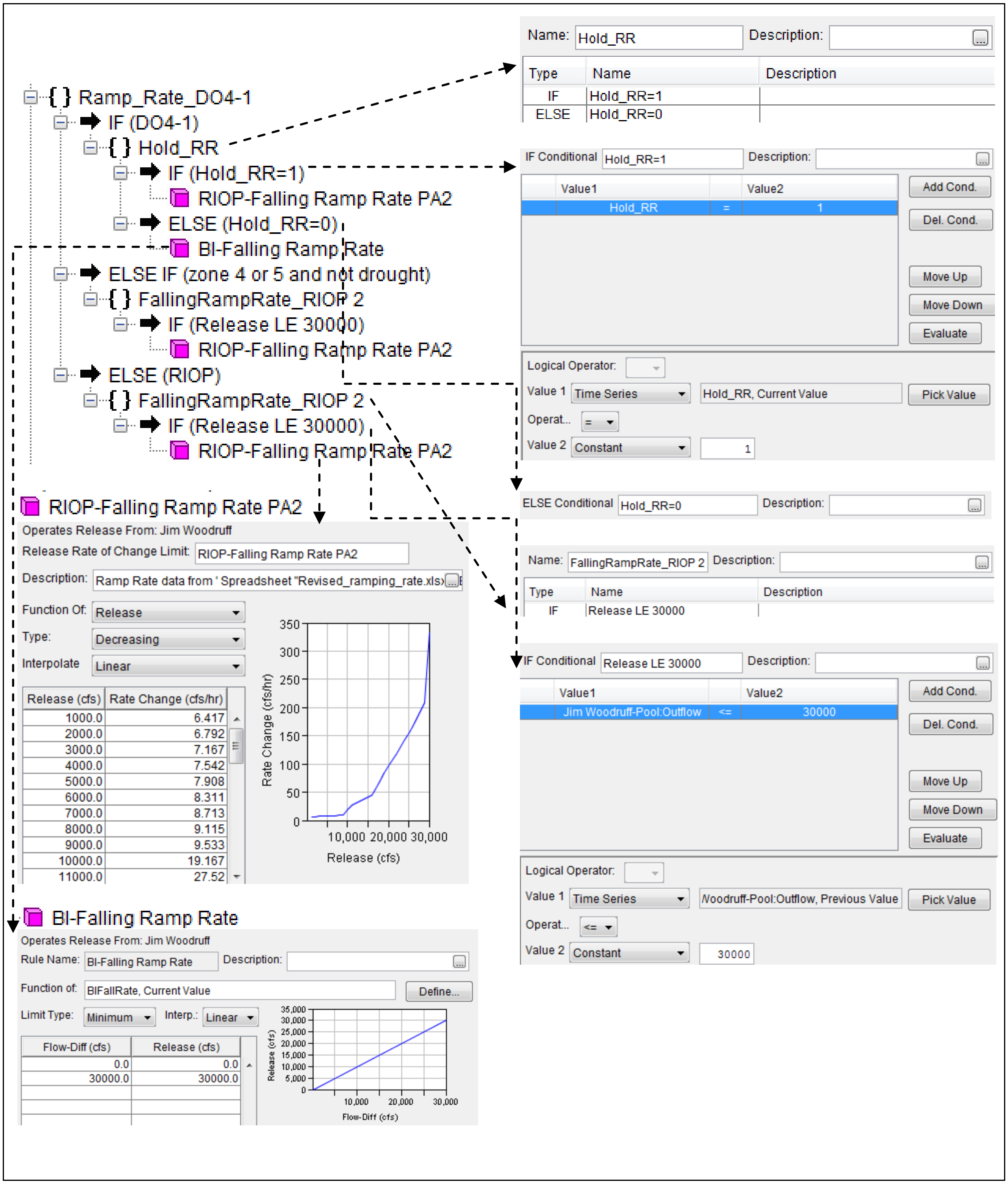


Figure K.47 Ramp_Rate_DO4-1 ("RIOP-Falling Ramp Rate" or "BI-Falling Ramp Rate")

9. { } Sturgeon Spawning

This conditional logic (see Figure K.48) represents the Corps' operation strategy for avoiding stranding Gulf sturgeon eggs and larvae when flows are declining from 40,000 cfs during the sturgeon spawning season from March through May. During a 2-week moving time window, when the releases from Jim Woodruff Dam are less than 40,000 cfs, the maximum drop from the Apalachicola River stage on the fourteenth day prior to the current day is 8 feet. A state variable named *MinStage_Chattahoochee* is created to determine the minimum stage on the Apalachicola River for the current day during the sturgeon spawning season. Using the stage-discharge rating curve on the Chattahoochee gage, a minimum flow release rule named *MinRel_forSturgeon* (Figure K.48) is established at Jim Woodruff Dam.

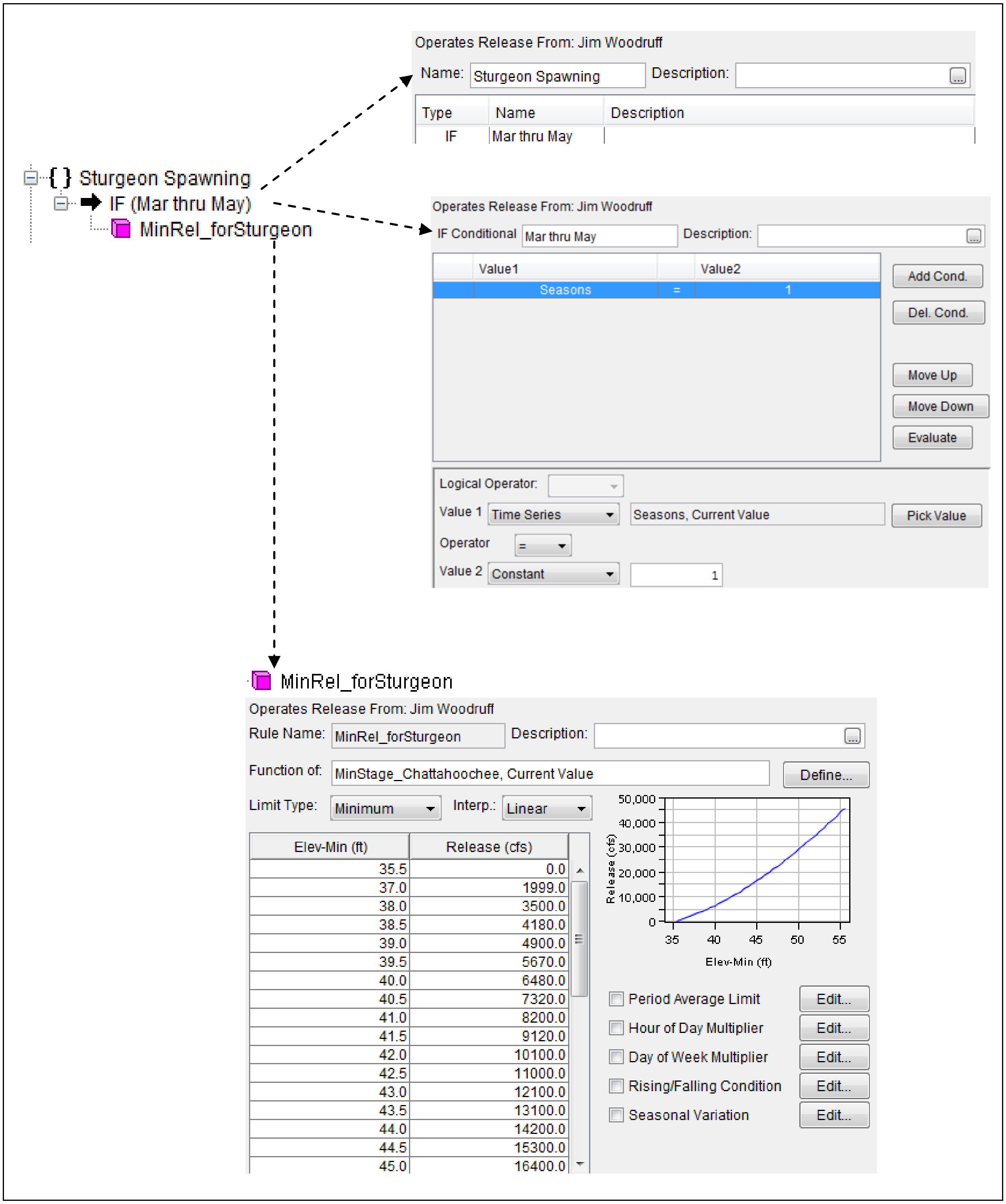


Figure K.48 Sturgeon Spawning -- "Conditional Blocks" and Rule at Jim Woodruff

10. { } Fish Spawning_Apalachicola River

The IF-Block and rule (see Figure K.49) 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 April 1 through June 1 on the Apalachicola River, the Corps shall operate generally stable or gradually declining river stages, which are defined as ramping down of half a foot per day or less.

To implement this fish spawning rule, the first step is to determine the maximum decrease in releases from Jim Woodruff as a function of reservoir releases. The fish spawning rule is applied at the Chattahoochee gage on the Apalachicola River. The calculations are shown as follows:

USGS Rating Curve at Station 02358000, "Apalachicola River at Chattahoochee, FL"
The same rating curve was used in the ResSim model at Junction, "Chattahoochee"

Flow (cfs)	Stage (ft)	Release from Woodruff (cfs)	Stage from rating (ft)	Maximum decline in stage in one day	Lowest allowable stage (ft)	Flow from rating curve	Flow decrease in one day	Flow decrease rate (cfs/hr)
3500	38	1000	36.16	0.5	35.66	318	682	28.4
4180	38.5	2000	36.9	0.5	36.40	1324	676	28.2
4900	39	3000	37.63	0.5	37.13	2317	683	28.5
5670	39.5	4000	38.37	0.5	37.87	3323	677	28.2
6480	40	5000	39.06	0.5	38.56	4266	734	30.6
7320	40.5	6000	39.7	0.5	39.20	5208	792	33.0
8200	41	7000	40.31	0.5	39.81	6172	828	34.5
9120	41.5	8000	40.89	0.5	40.39	7135	865	36.0
10100	42	9000	41.43	0.5	40.93	8077	923	38.5
11000	42.5	10000	41.95	0.5	41.45	9028	972	40.5
12100	43	12000	42.95	0.5	42.45	10910	1090	45.4
13100	43.5	14000	43.91	0.5	43.41	12920	1080	45.0
14200	44	16000	44.82	0.5	44.32	14904	1096	45.7
15300	44.5	18000	45.71	0.5	45.21	16862	1138	47.4
16400	45	20000	46.54	0.5	46.04	18796	1204	50.2
17500	45.5	24000	48.12	0.5	47.62	22712	1288	53.7
18700	46	28000	49.61	0.5	49.11	26608	1392	58.0
19900	46.5	32000	51.03	0.5	50.53	30584	1416	59.0
21200	47	36000	52.4	0.5	51.90	34520	1480	61.7
22400	47.5	40000	53.7	0.5	53.20	38440	1560	65.0
23700	48	44000	54.97	0.5	54.47	42404	1596	66.5
25000	48.5	48000	56.19	0.5	55.69	46346	1654	68.9
26300	49	52000	57.25	0.5	56.75	49850	2150	89.6
27700	49.5	57000	58.19	0.5	57.69	54326	2674	111.4
29100	50	62000	59.09	0.5	58.59	59204	2796	116.5
30500	50.5	67000	59.93	0.5	59.43	63994	3006	125.3
31900	51	72000	60.76	0.5	60.26	68960	3040	126.7
33400	51.5	77000	61.55	0.5	61.05	73820	3180	132.5

The next step is to establish a Release Rate of Change Limit rule, *RiverStage_FallingLimit* (Figure K.49), similar to the *Falling Release Ramp Rate* rule in the RIOP operating, and apply it to Jim Woodruff. It should be noted that the fish spawning rule for the Apalachicola River is applicable only when the release from Jim Woodruff is equal to or less than 30,000 cfs (Source: conference call discussions on January 20, 2010).

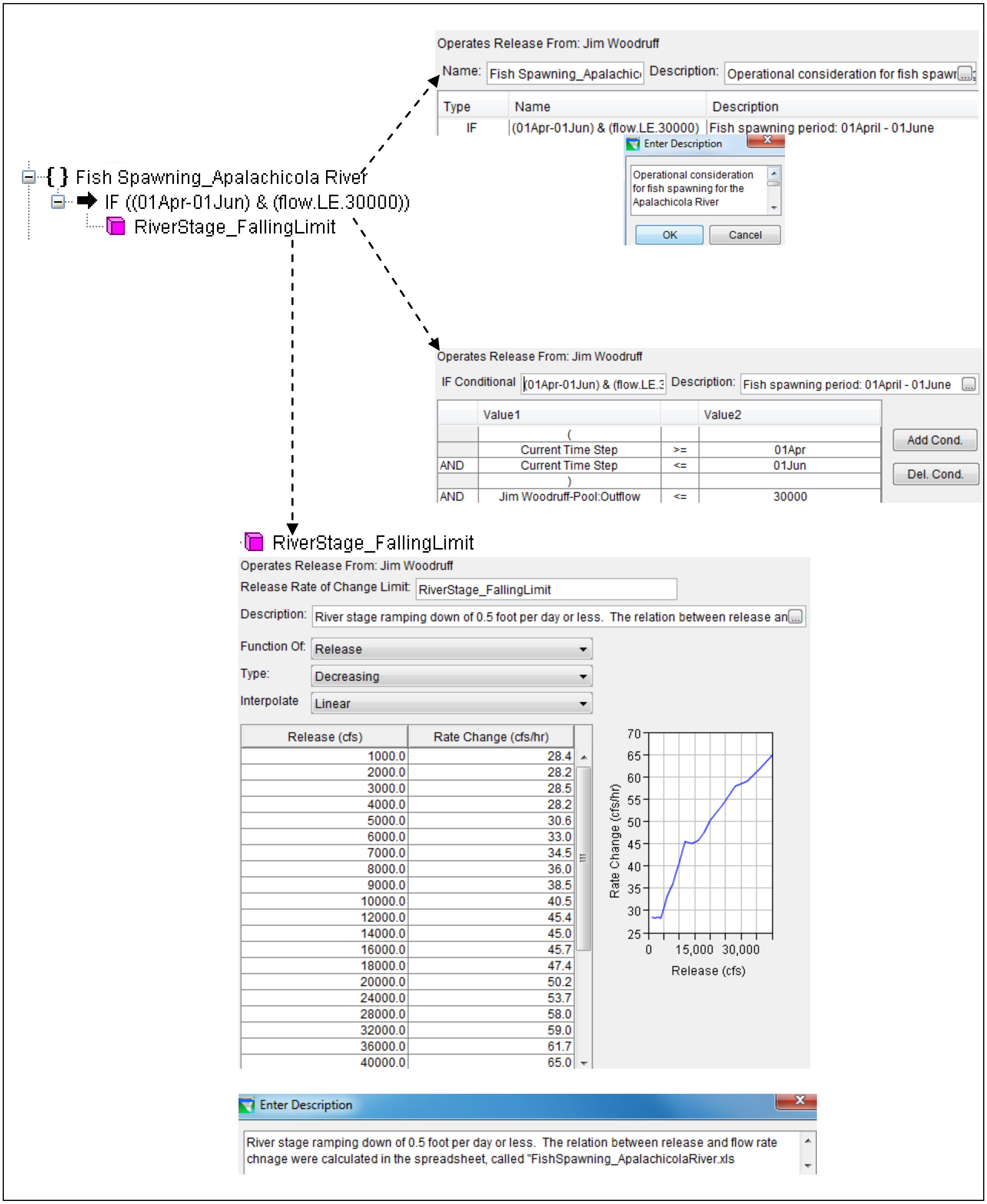


Figure K.49 Fish Spawning on the Apalachicola River -- "Conditional Blocks" and Rule at Jim Woodruff

11. { } Fish Spawning_Jim Woodruff

This conditional logic (see Figure K.50 through Figure K.51) represents operation requirements for fish spawning in accordance with the procedures of SAM SOP 1130-2-9. During the spawning period, which is March 1 to May 1 for Lake Seminole, 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 H.

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 in as follows:

```
# State variable: JimWoodruff_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
```

The state variable *JimWoodruff_Elev_State* script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is described in Appendix H.

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 K.50 through Figure K.51). To maintain a gradually dropping pool, the following limits of pool elevation changes within 24 hours are applied:

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

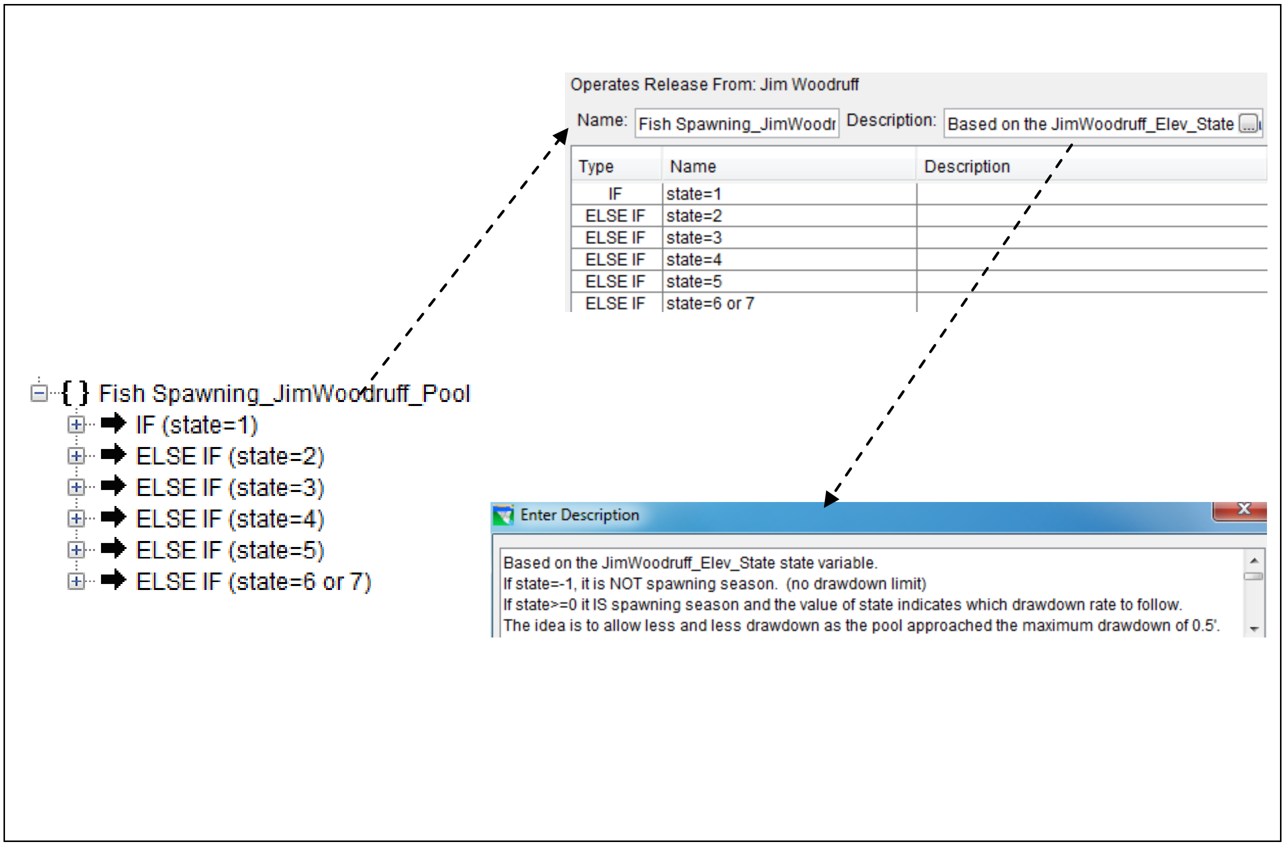


Figure K.50 Fish Spawning at Jim Woodruff -- "Conditional Blocks" at Jim Woodruff

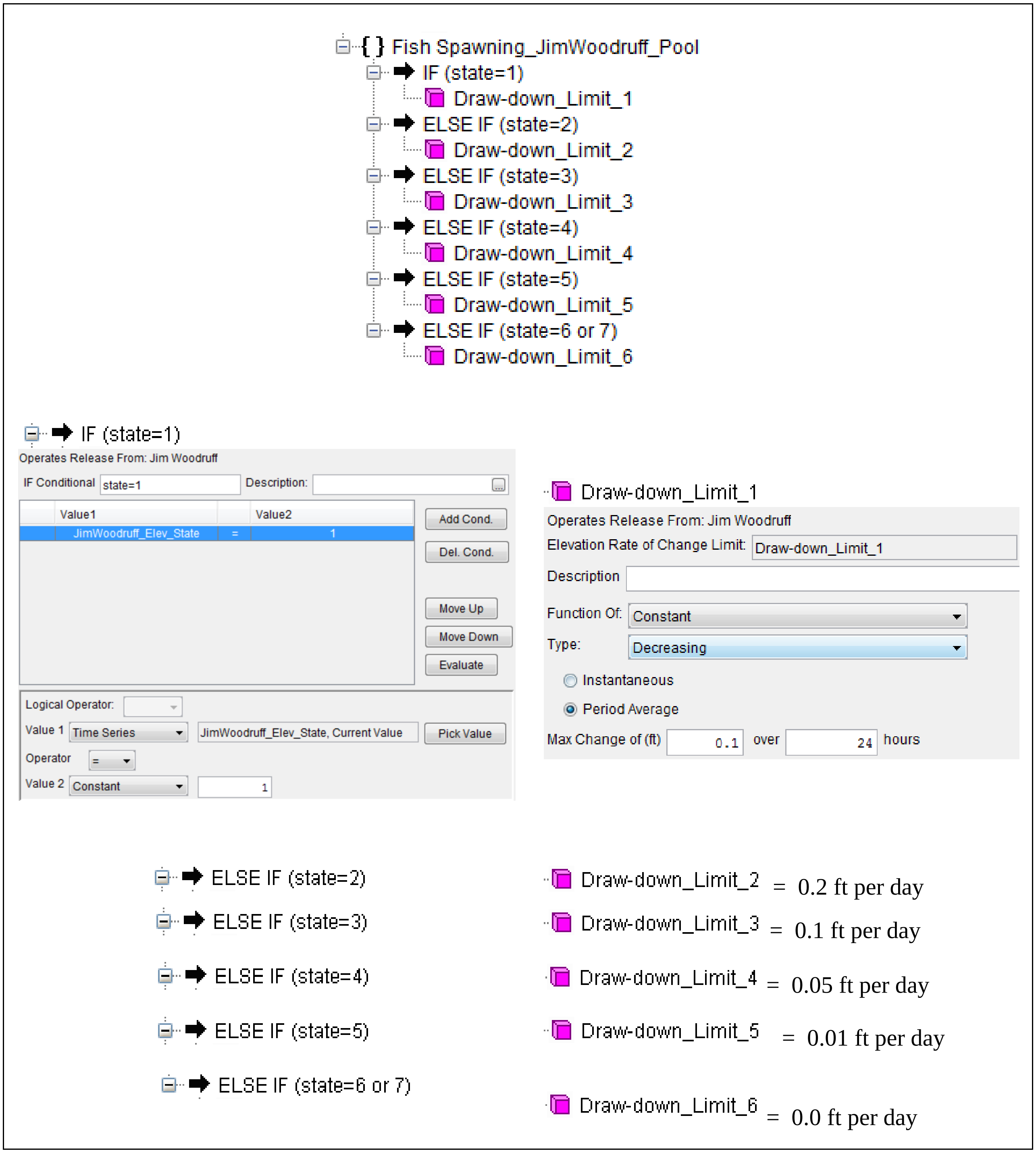


Figure K.51 Fish Spawning at Jim Woodruff -- "IF-Blocks" and "Rules" at Jim Woodruff

12. Release inflow up to Minimum Reqmt

This conditional logic (see Figure K.52) represents the release relationship between inflow to Jim Woodruff and dam releases in the Operating Inactive zone. There are two minimum release rules to reduce impacts from zone boundary restriction in the Operating Inactive zone. Depending on the value of the Exceptional Drought Operations (EDO), the minimum flow requirements ranges between 4550 cfs and 5050 cfs.

a. MinInflow_to4550

If in Exceptional Drought Operations (EDO = 1), then release inflow into Lake Seminole (up to 4550 cfs).

b. MinInflow_to5050

If in Normal or Drought operations (EDO = 0), then release inflow into Lake Seminole (up to 5050 cfs).

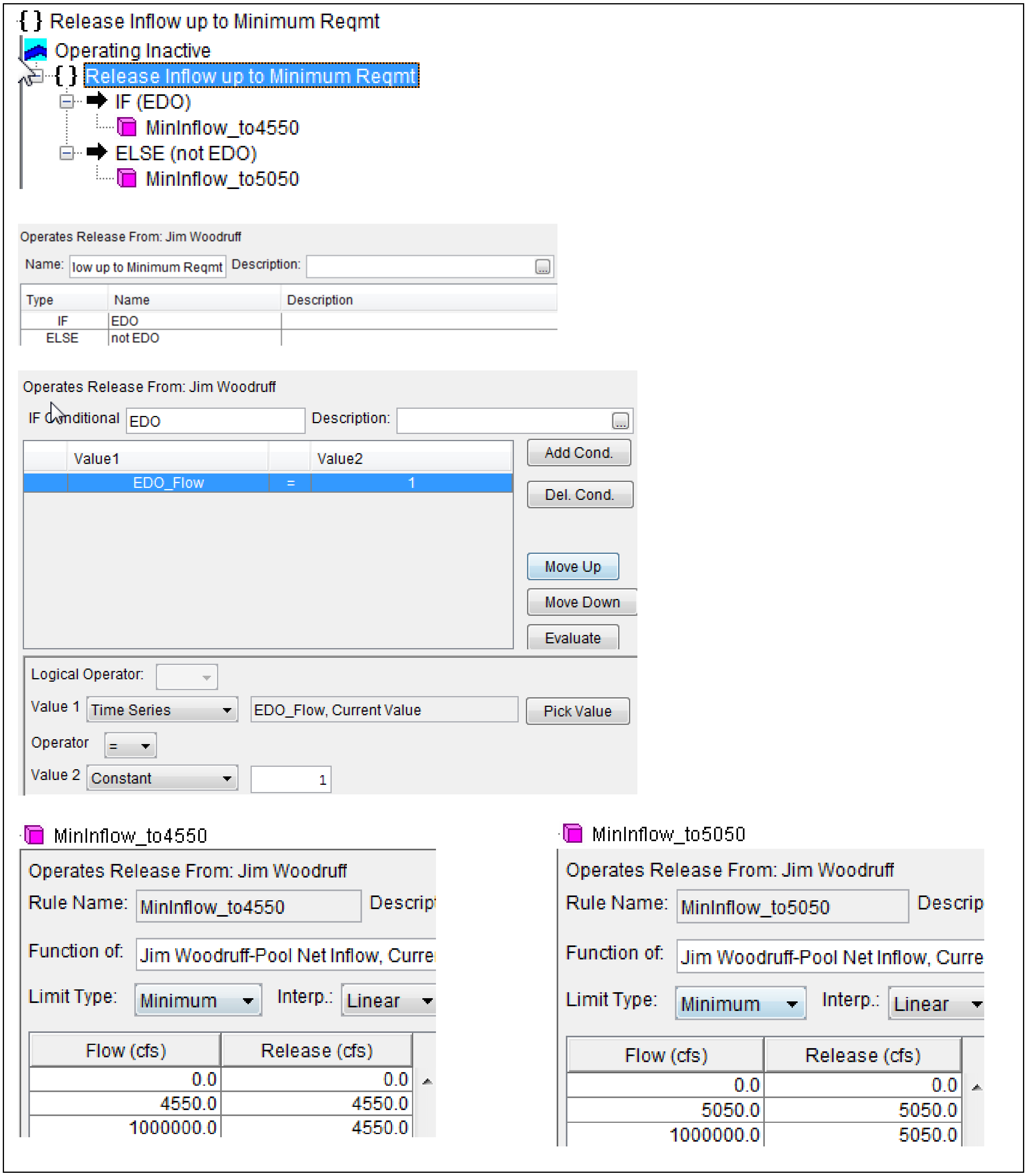


Figure K.52 ***Release inflow up to Minimum Reqmt*****-- "IF-Blocks" and "Rules" at Jim Woodruff**

III. Alt1

Alt1 is a copy of NOAction alternative, but have Glades and Bear Creek reservoirs in the system. Table K.05 shows the operation sets used in the Alt1 alternative.

Table K.05 Operation Sets Used in Alt1 Alternative

Project	Operation Set	Described Previously
Glades	**NO-Action**	No
Buford	NO-Action	Yes
Morgan Falls	NO-Action	Yes
Bear Creek	**NO-Action**	No
West Point	NO-Action	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	NO-Action	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	NO-Action	Yes

A. Glades

The NO-Action operation set was used in the NOAction alternative at Glades. The project contains three zones. The zones include Flood Control, Conservation, and Inactive. The Inactive zone contains no rules. The rule set for the NO-Action operation set for Glades is shown in Figure K.53.

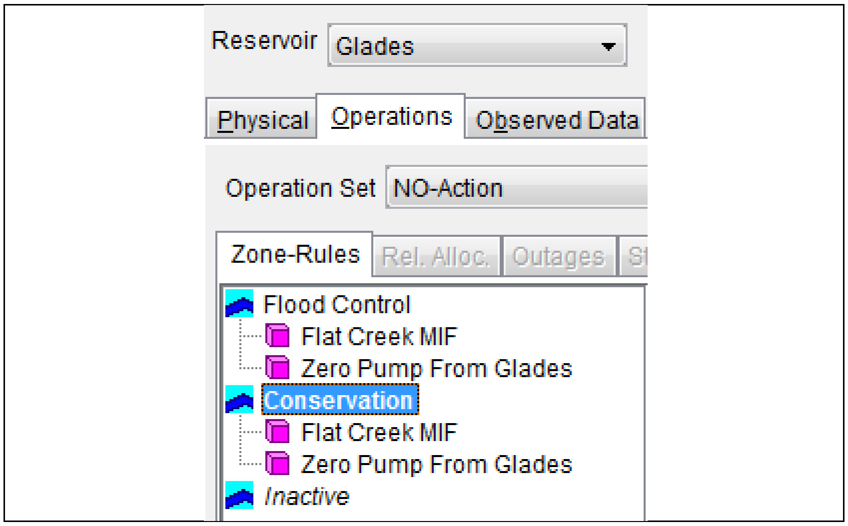


Figure K.53 Rule Set for Glades NO-Action Operation Set

1. *Flat Creek MIF*

This rule (see Figure K.54) represents the flow release from the dam. The proposed dam is designed to pass the annual 7-day, 10-year minimum flow (7Q10) of Flat Creek, estimated at 4.6 cubic feet per second (cfs) or the natural inflow, whichever is less.

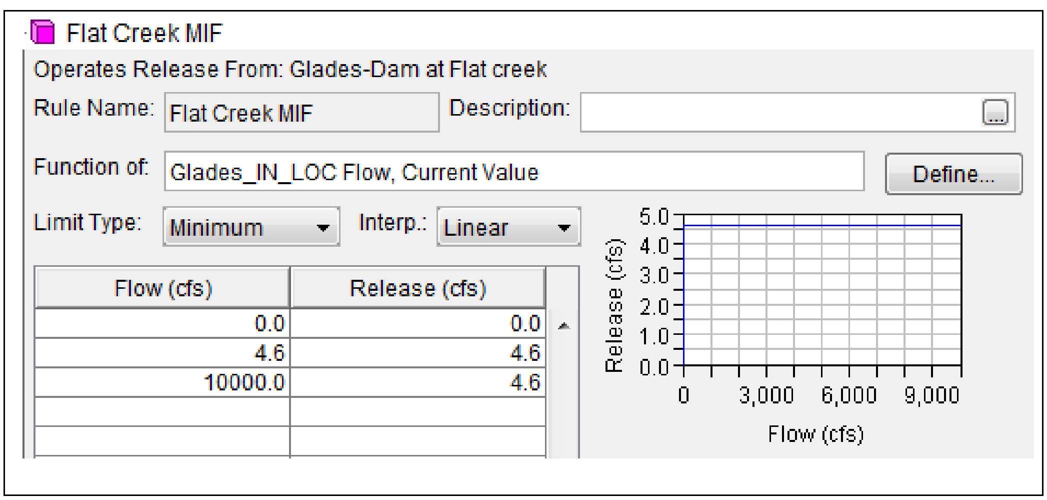


Figure K.54 Glades Reservoir – *Flat Creek MIF* rule

2. *Zero Pump From Glades*

This rule (see Figure K.55) represents the water supply diversion from Glades to Buford_IN. Currently this rule is set to zero.

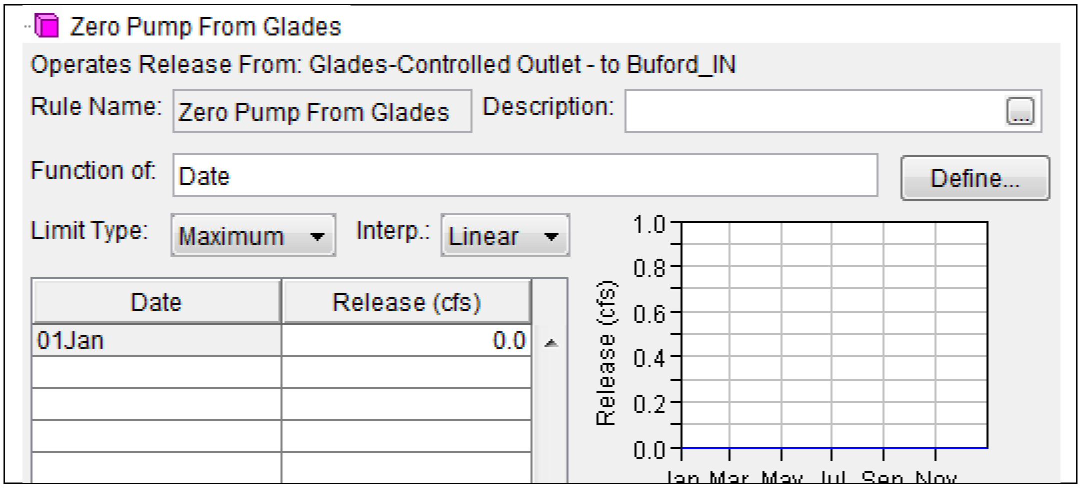


Figure K.55 Glades Reservoir – Zero *Pump From Glades* rule

3. *Pump from Chattahoochee River to Glades Reservoir*

The Chattahoochee River Pump Station will pump to Glades Reservoir when flow in the River just upstream of the pump station exceeds the annual 7Q10 (183.5 cfs), and when water level in Glades Reservoir is lower than 1,180 ft MSL. When the flow rate in the Chattahoochee River is less than or equal to the annual 7Q10, the pump station will not operate, even if Glades Reservoir's water level is lower than 1,180 ft MSL. The state variable that determines how much to pump to Glades pool each time step is called "PumpToGlades". This state variable needs to access the Glades' pool elevation at each time step. In order to have the "PumpStation_IN" junction and Glades reservoir in the same compute block to that the pool elevation is accessible to the state variable script, a diversion named "Dummy Div" was added to the "PumpStation_IN" junction and specified to be function of Glades_Pool Elevation. The diversion function is zero for all values of pool elevation so that the "Dummy Div" diverts no water from the system.

Figure K.56 illustrates how the "ToGlades" diversion was defined. Note that the diversion is a function of the state variable "PumpToGlades" and the function in the table is a one-to-one relationship up to 60.3 cfs, the pump capacity specified by the applicant.

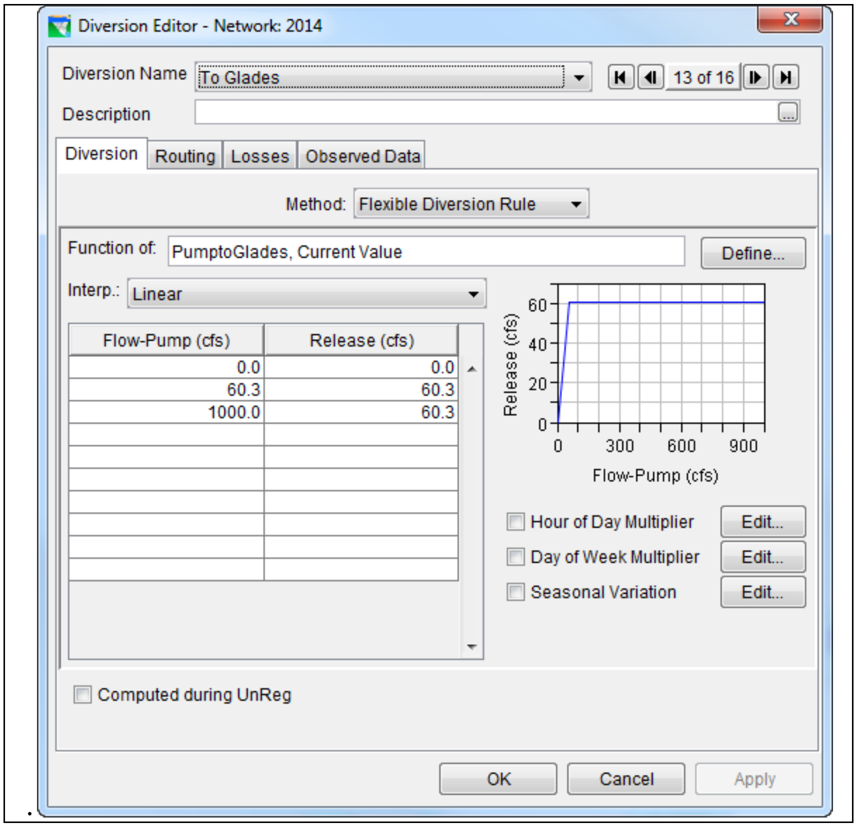


Figure K.56 Diversion Editor – Network 2014: To Glades

B. Bear Creek

The NO-Action operation set was used in the NOAction alternative at Bear Creek. The project contains three zones. The zones include Flood Control, Conservation, and Inactive. The Inactive zone contains no rules. The rule set for the NO-Action operation set for Bear Creek is shown in Figure K.57.

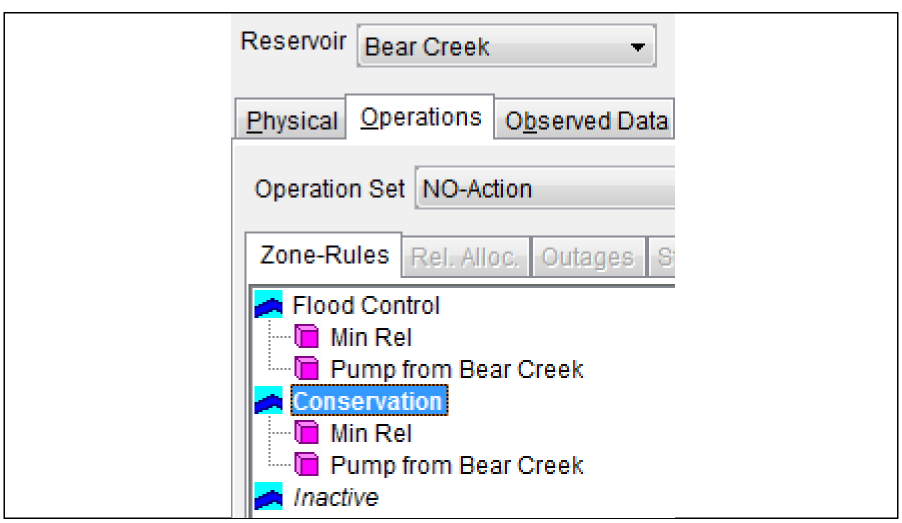


Figure K.57 Rule Set for Bear Creek NO-Action Operation Set

1. Min Rel

This rule (see Figure K.58) represents the minimum required release from the dam which is the sum of a 2 cfs Non-Depletable Flow (NDF) and a 1.1 cfs Minimum Instream Flow (MIF). If the reservoir inflow is less than the stipulated amount, then reservoir inflow will be released.

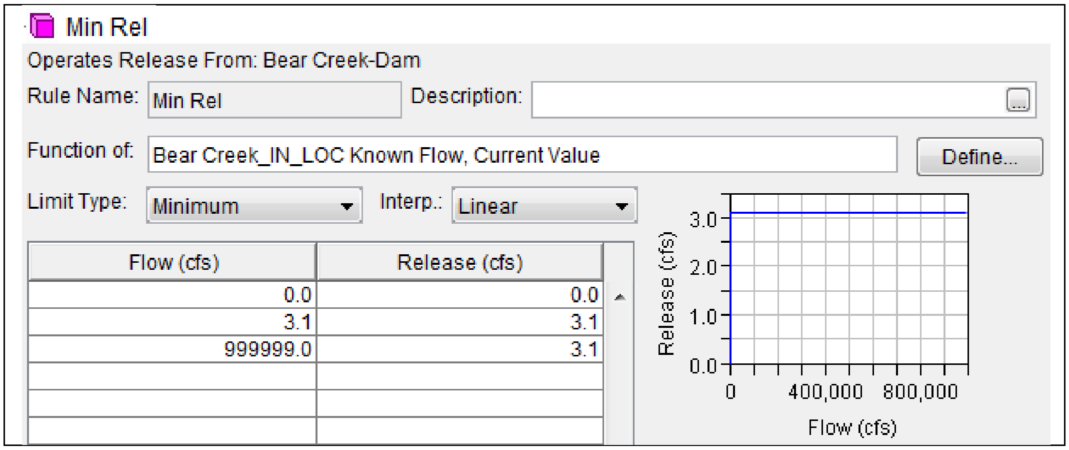


Figure K.58 Bear Creek Reservoir –*Min Rel* rule

2. Pump From Bear Creek

This rule (see Figure K.59) represents the daily “safe yield” water supply withdrawal of 25.4 cfs from Bear. The return flow is assumed to be 70% of the diverted amount and is returned to Chattahoochee River. The return flow is specified in the losses definition for the diverted outlet’s routing reach (Figure K.60).

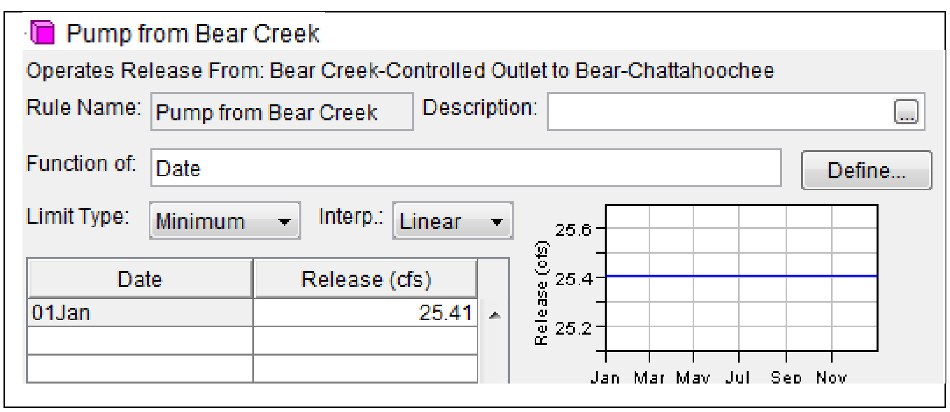


Figure K.59 Bear Creek Reservoir –*Pump From Bear Creek* rule

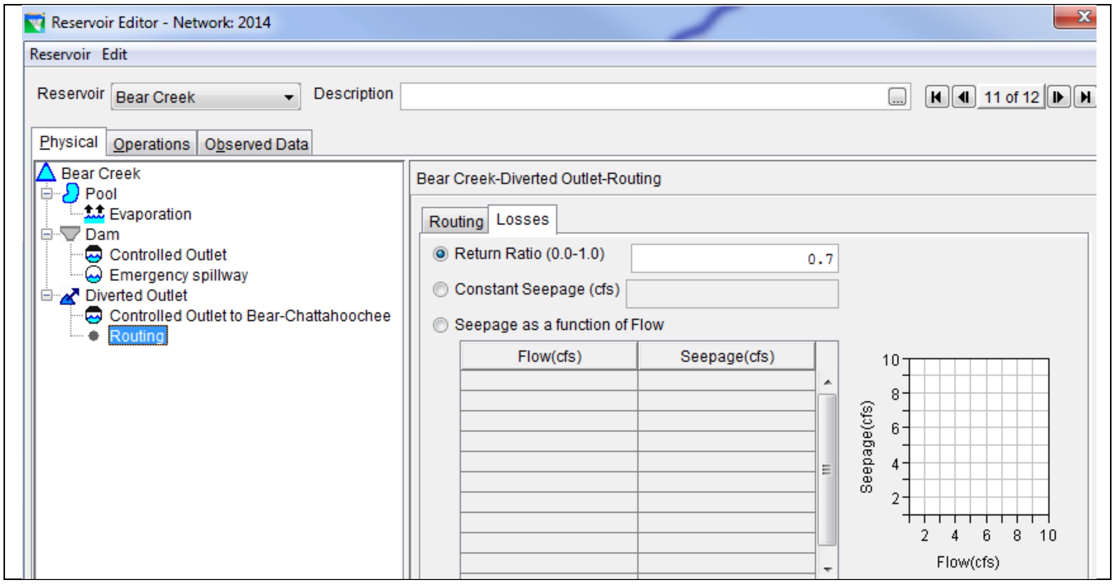


Figure K.60 Bear Creek-Diverted Outlet-Routing

3. Pump from Chattahoochee River to Bear Creek Reservoir

Pump station diversion was included in the model to supply water to Bear Creek Reservoir. The diversion from the Chattahoochee River is located just upstream of the confluence with Bear Creek. Pumping is assumed to occur whenever the reservoir level falls below 80% of full reservoir storage (EL 750.7906) as long as adequate water remains in the Chattahoochee River. If the reservoir is below 80% of full storage at the end of the day (without diversion pumping), the lesser of the following volumes is computed and delivered to the reservoir:

- The amount of pumping needed to refill the reservoir to 80% capacity
- The designated diversion pumping capacity (21.5 cfs)
- The diversion volume that can be accommodated considering Low Flow Requirements in the Chattahoochee River

The state variable "PumptoBear" is used to determine the amount of pumping in each time step within the restrictions described above. The Pump Station diversion is defined to be a one-to-one function of the state variable value in each timestep. Figure K.61 shows the definition of diversion.

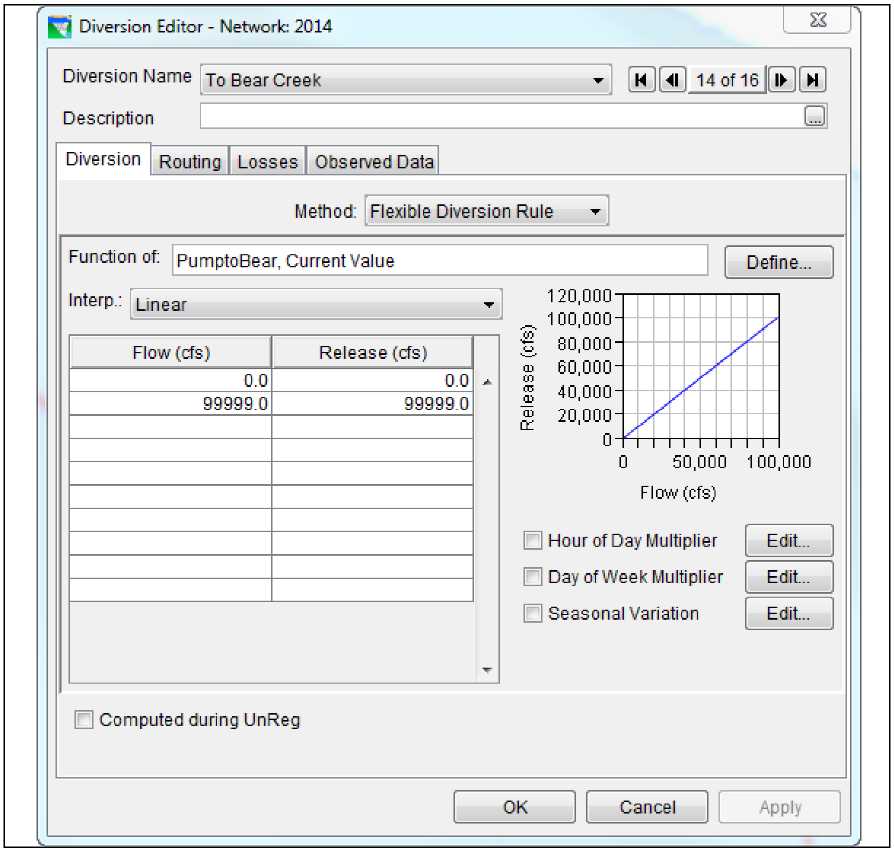


Figure K.61 Diversion Editor-To Bear Creek

IV. Alt2

In the **Alt2** alternative, *four projects* have an operation set that is *different from the Alt1* alternative. These projects are *Buford, West Point, Walter F George, and Jim Woodruff*. Table K.06 shows the operation sets used in the Alt2 alternative. The differences in the operation sets are discussed in the following sections.

Table K.06 Operation Sets Used in Alt2 Alternative

Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	**Silver**	No
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	**Silver**	No
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	**Silver**	No
George Andrews	Flow-thru	Yes
Jim Woodruff	**Silver**	No

A. Buford

The Silver operation set for Buford retains all the rules and settings from NO-Action operation set except that Silver uses different elevation of action zones labeled as *Revised* Action Zones, modified power generation Schedule with Drought Operation, and Seasonal Minimum Flow at Peach Tree Creek.

1. Revised Action Zones

Differences in settings in Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. Buford's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised Action Zones are shown in Table K.07, and the comparison to the action zones in No-Action Operation Set is shown in Figure K.62.

Table K.07 Revised Action Zone Elevations for Silver Operation set at Buford

Zones	1-Jan	1-Feb	1-Mar	15-Apr	1-May	1-Jul	1-Oct	1-Dec
Top of Dam	1106							
Flood Control	1085							
Conservation	1070			1070	1071		1071	1070
Zone 2	1066	1068				1068		
Zone 3	1063	1066.5				1066.5		
Zone 4	1060		1065			1065		
Operating Inactive	1035							

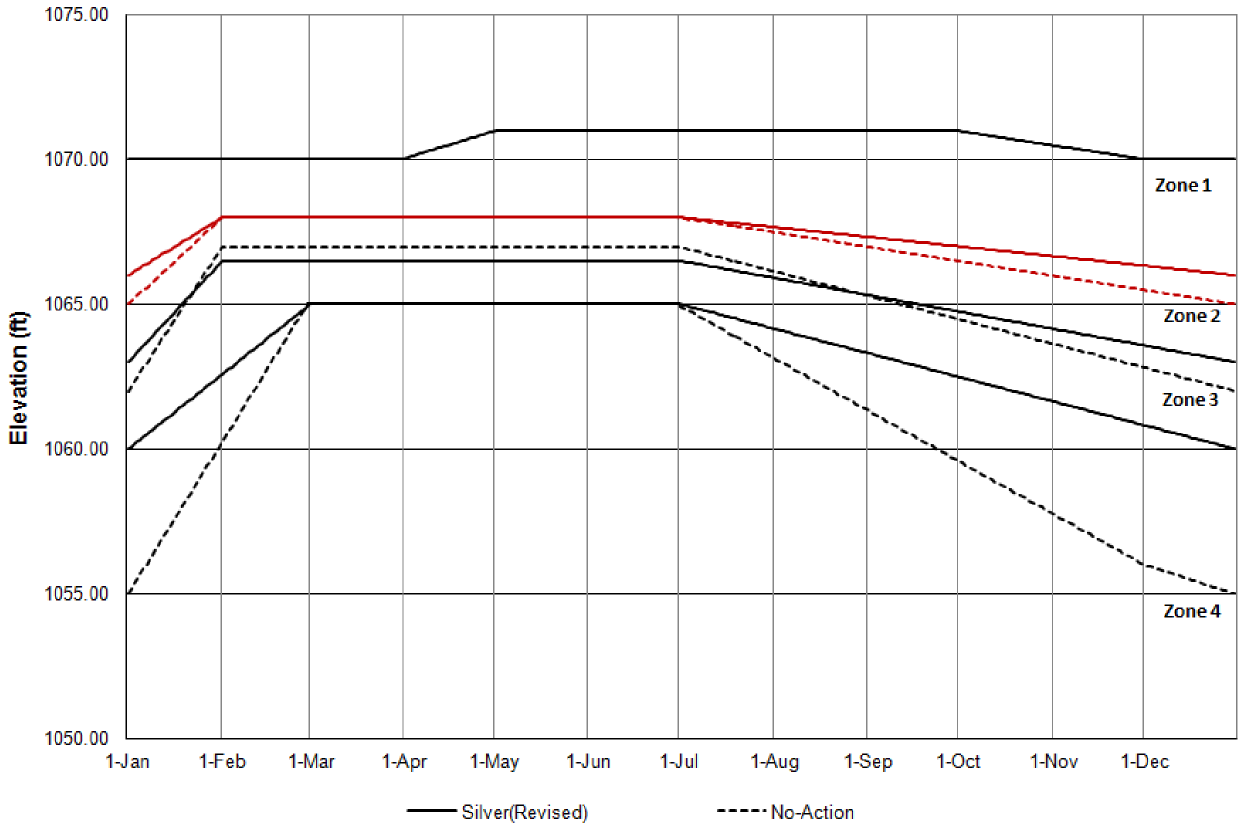


Figure K.62 Comparison of NO-Action and Revised Action Zones at Buford

2. Modified Power Generation Schedule with Drought Operation

Updated hydropower generation rules implement the Power Guide Curve operation where the power requirement is defined using a Plant Factor. This parameter is a function of storage and the requirement of specific hours of generation that varies by zone.

The rules are composed of a conditional statement with two rules that are initiated based on the value of the state variable, *DroughtOperations_DO4-1,* which determines whether or not the system's composite storage is within the drought zones. If storage conditions are met and the state variable equals 1, then the first conditional statement initiates an equivalent of 1 or 2 hours of weekday generation at full capacity within Flood Control, Conservation, Zone 2, and Zone 3. If the composite storage state does not meet the conditions in the state variable, the second condition initiates the equivalent of 2 or 3 hours of generation at full capacity. The settings for these rules are shown in Figure K.63 through Figure K.66.

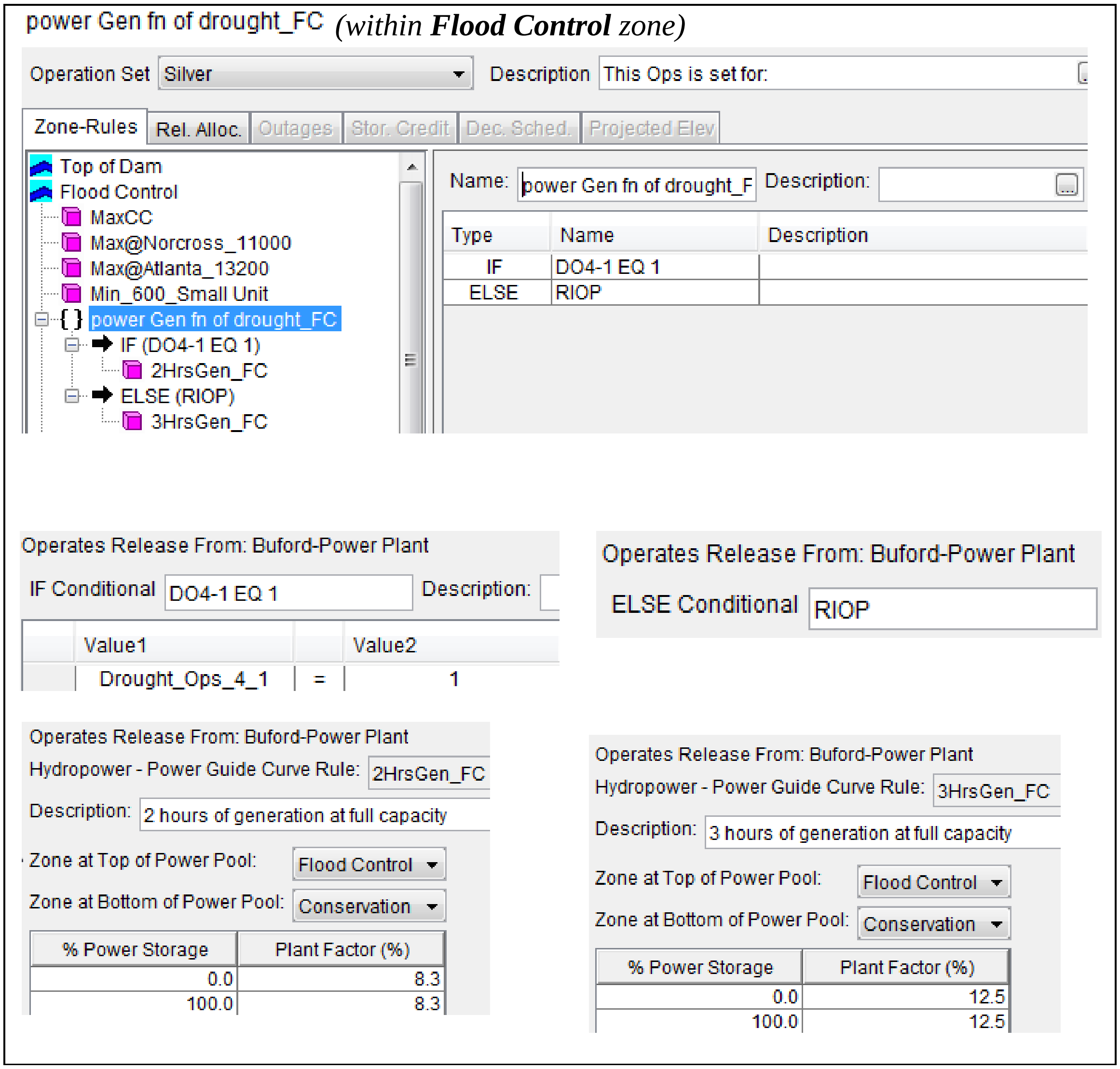


Figure K.63 Silver Operation Set Hydropower Rules for Flood Control Zone

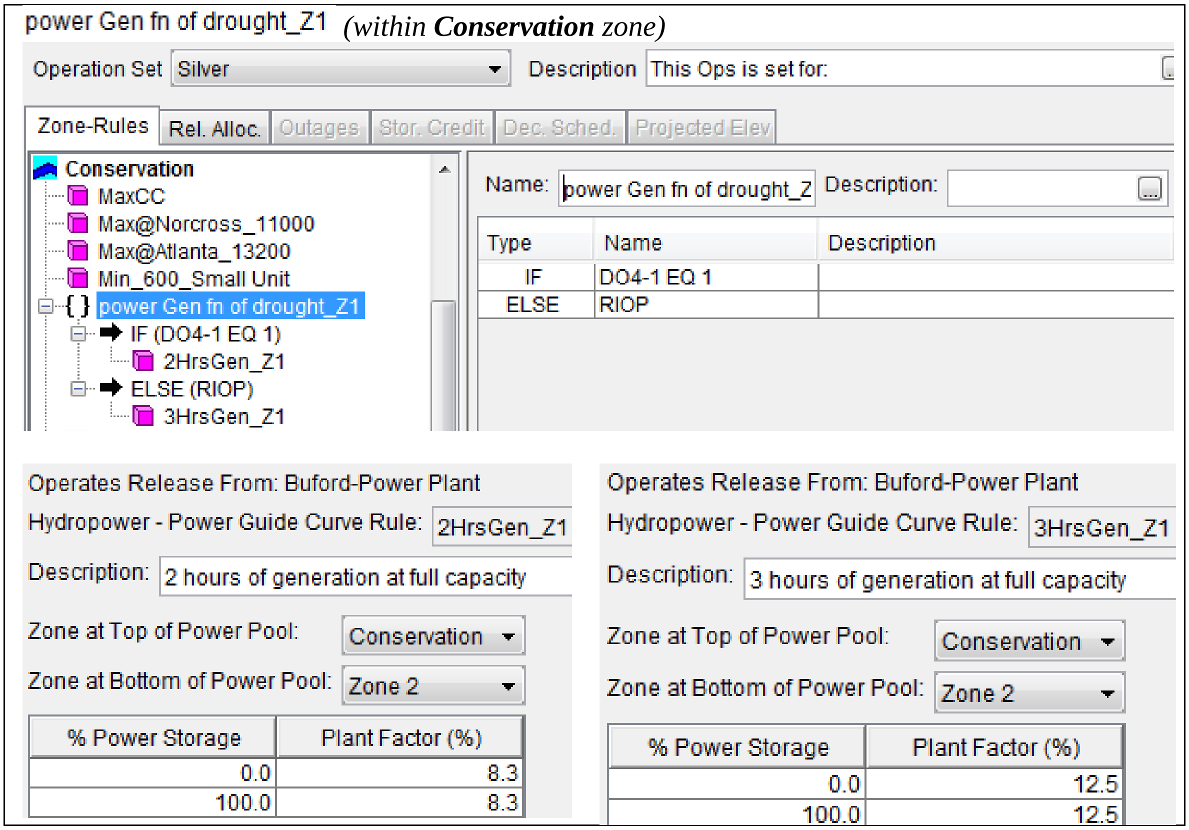


Figure K.64 Silver Operation Set Hydropower Rules for Conservation zone

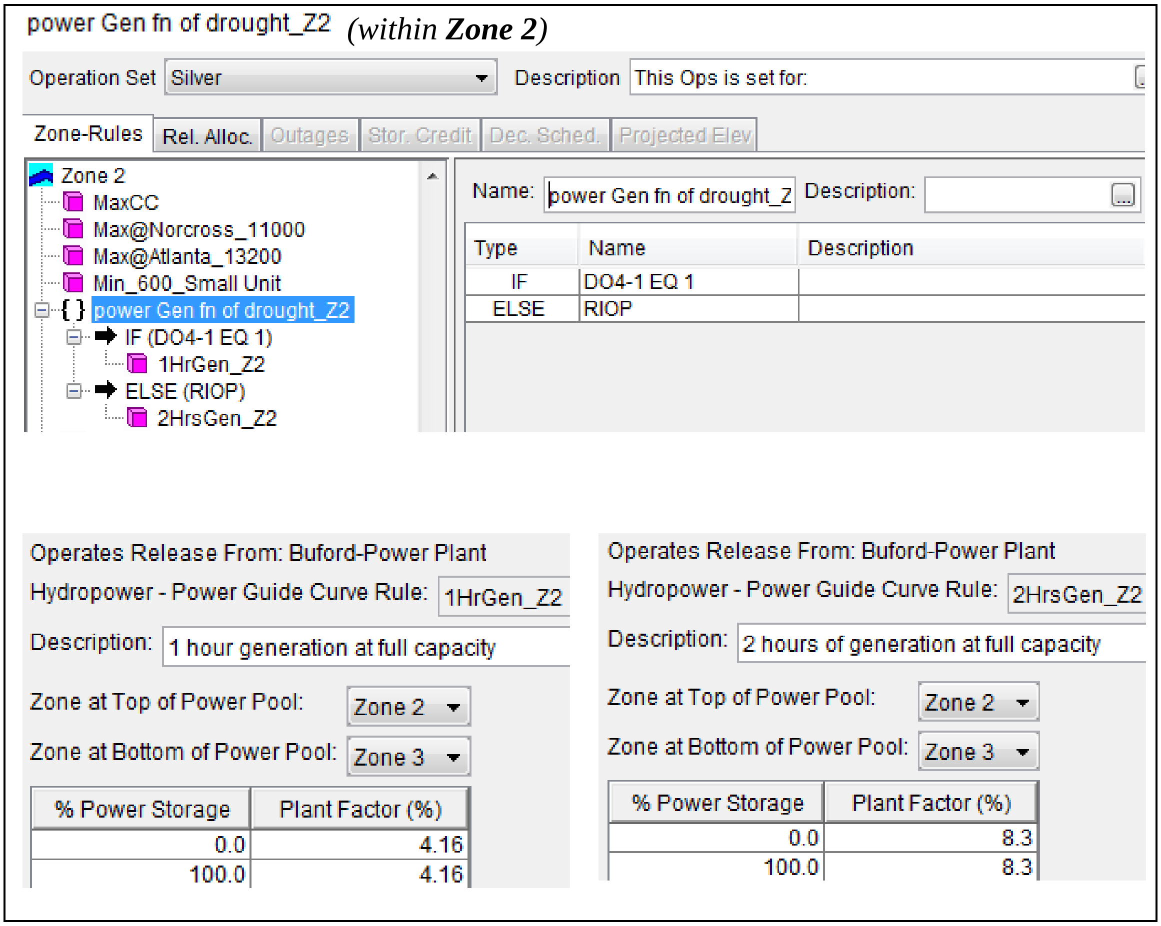


Figure K.65 Silver Operation Set Hydropower Rules for Zone 2

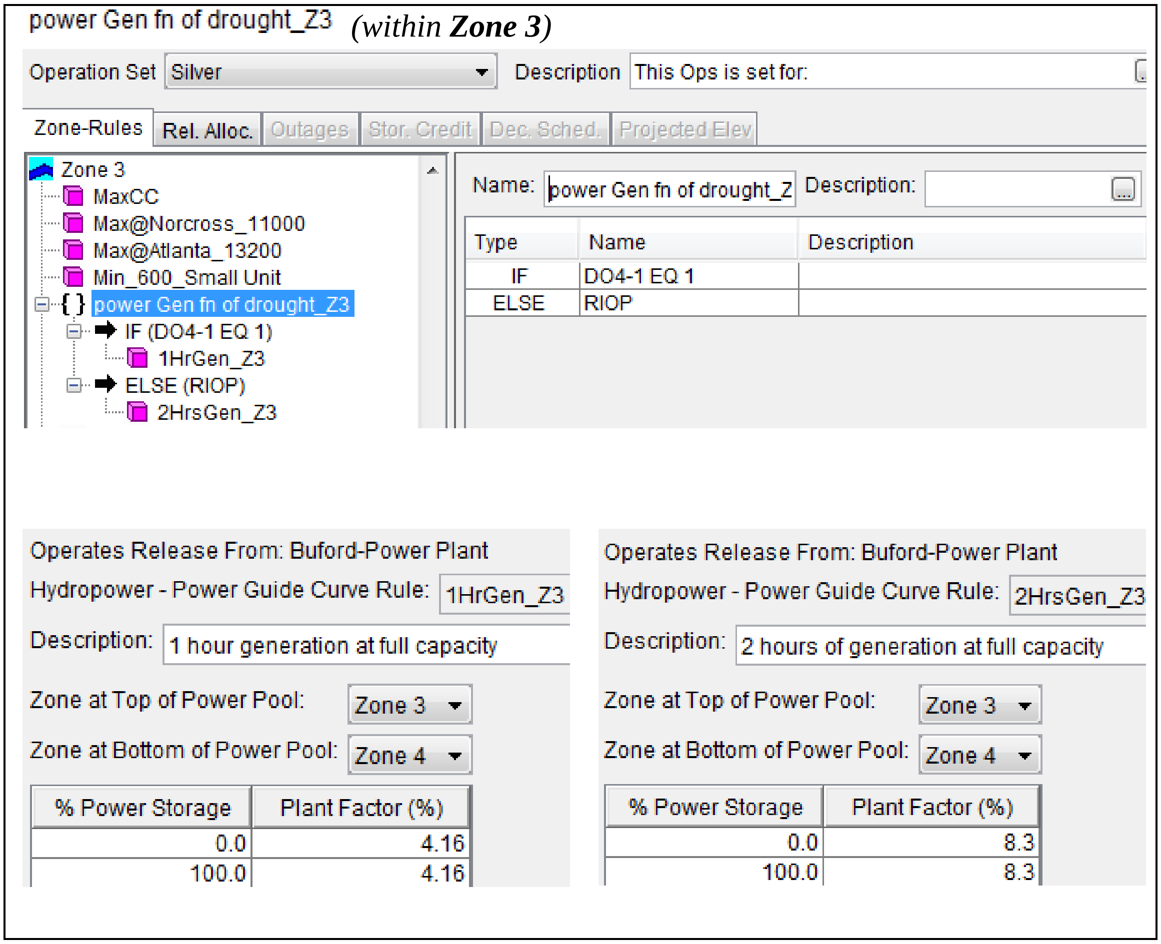


Figure K.66 Silver Operation Set Hydropower Rules for Zone 3

3. *Seasonal Minimum Flow at Peach Tree Creek*

The Silver operation set modifies the minimum flow rule at Peach Tree Creek to implement a seasonal approach, reflecting the goal to provide a minimum water quality flow of 750 cfs in Chattahoochee during May-Oct, and 650 cfs during Nov-Apr. The model uses 800 cfs and 700 cfs respectively to add a “factor of safety” to guarantee the minimum flow. Description of the rule is shown in Figure K.67.

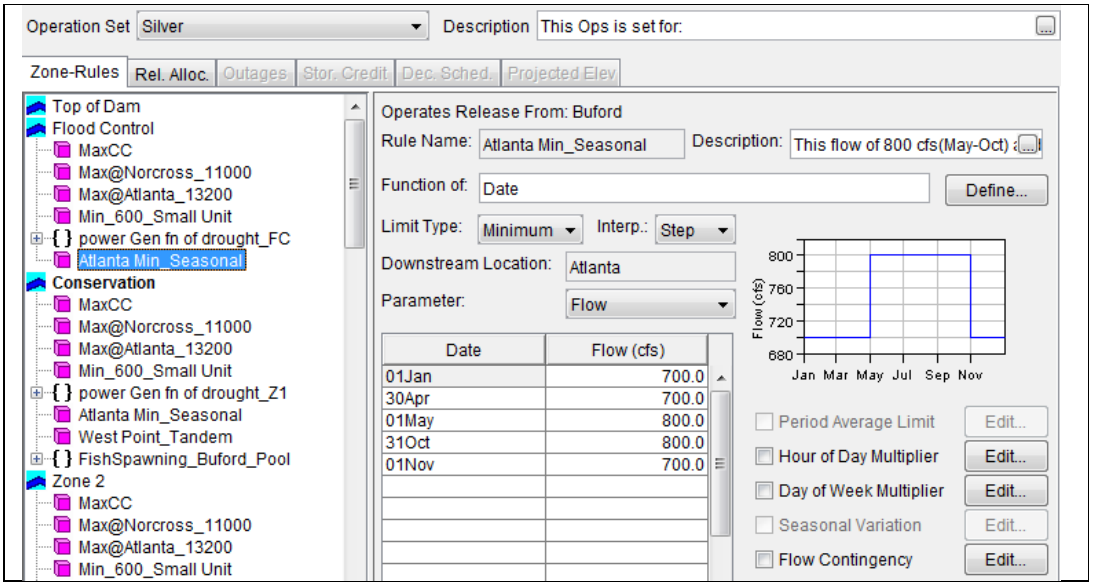


Figure K.67 Silver Operation Set Seasonal Minimum Flow rule at Peach Tree Creek

B. West Point

Silver operation set for West Point retains all the rules and settings from NO-Action operation set except this alternative uses different elevation of action zones labeled as *Revised* Action Zones.

1. Revised Action Zones

Differences in settings in Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. West Point's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised Action Zones are shown in Table K.08, and the comparison to the action zones in No-Action Operation Set is shown in Figure K.68.

Table K.08 Revised Action Zone Elevations for Silver Operation Set

Zones	1-Jan	1-Feb	15-Feb	1-May	1-Jun	1-Jul	1-Sep	1-Nov	1-Dec	15-Dec
Top of Dam	652									
Flood Control	641									
Conservation	628		628		635			635		628
Zone 2	627.5		627.5	632.25	632.5		632.5		627.5	
Zone 3	623	623		632		632	629.5		623	
Zone 4	621	621		631	631				621	
Inactive	620									

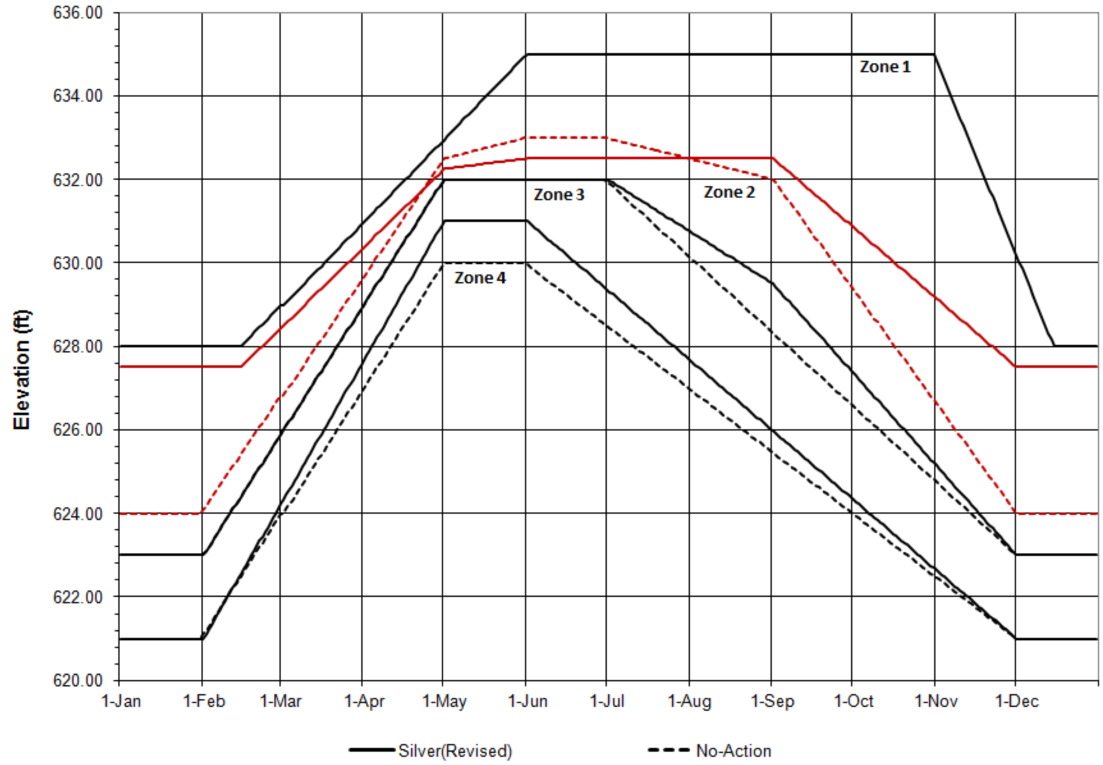


Figure K.68 Comparison of NO-Action and Reviesd Action Zones at West Point

C. Walter F George

Silver operation set for Walter F George retains all the rules and settings from NO-Action operation set except this alternative uses different elevation of action zones labeled as *Revised* Action Zones.

1. Revised Action Zones

Differences in settings in the Silver operation set consist of changes in elevation of operational zones Zone 2, Zone 3 and Zone 4. Walter F George's action zone definitions were revised as part of the objective to formulate action zones that eliminate disproportionate impact on reservoirs. Revised Action Zones are shown in Table K.09, and the comparison to the action zones in NO-Action Operation Set is shown in Figure K.69.

Table K.09 Revised Action Zone Elevations for Silver Operation Set

Zones	1-Jan	1-Mar	1-May	1-Jun	1-Sep	1-Oct	1-Dec
Top of Dam	215						
Max Flood	199						
Flood Control	190						
Conservation	188		188	190		190	188
Zone 2	187.5						
Zone 3	185.5	185.5	187		187		185.5
Zone 4	184.5	184.5	186.75		185		
Inactive	184						

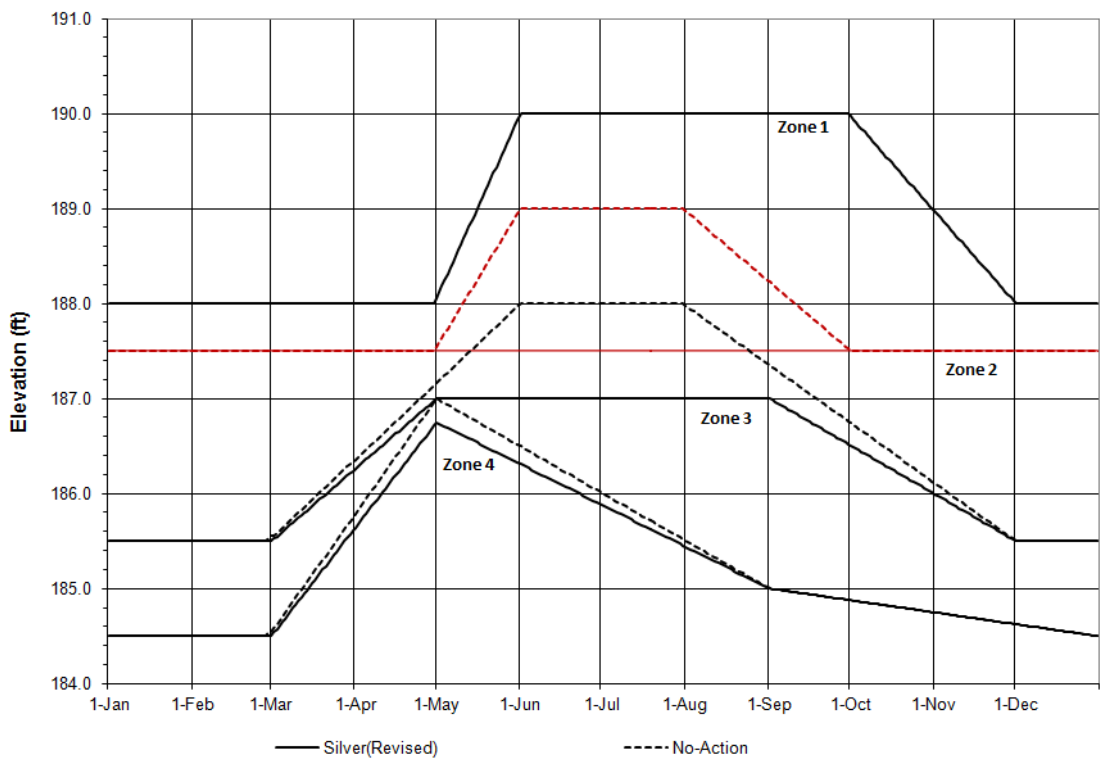


Figure K.69 Comparison of NO-Action and Reviesd Action Zones at Walter F. George

D. Jim Woodruff

Silver operation set for Jim Woodruff retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to navigation and suspending ramp rate during prolonged low flow operation.

1. Navigation (4-5 month) _DO4-1

Navigation operation rules were added to the current operation set to model the feasibility of a five month navigation season from January through May. The goal is to maintain a flow rate of 16,200 cfs at Blountstown as much as possible, which represents 7 ft of minimum navigation depth. The added rule apply consistently within the five conservation zones, at a lower priority than the "Flow Target" logic but higher priority than the "Sturgeon Spawning" rules.

Nested conditional statements use existing RIOP state variables as well as one named *NavigationSeason*, which indicates whether the release decision occurs during January-May. If true, and if the system composite storage zone is 1 or 2 and not under drought operations then the minimum release rule *MinRel_Navigation* specifies release. The settings are shown in Figure K.70 and Figure K.71. Description of the state variables can be found in Appendix H.

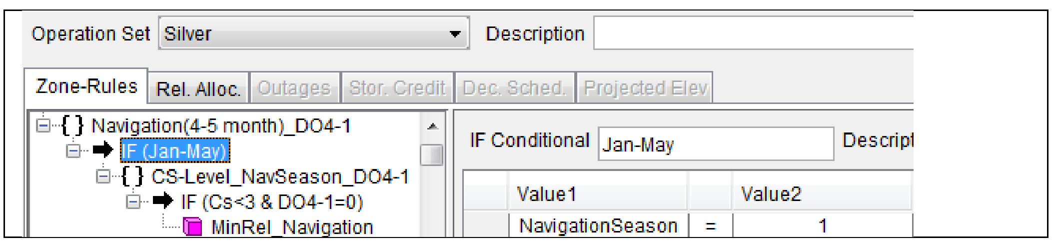


Figure K.70 Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

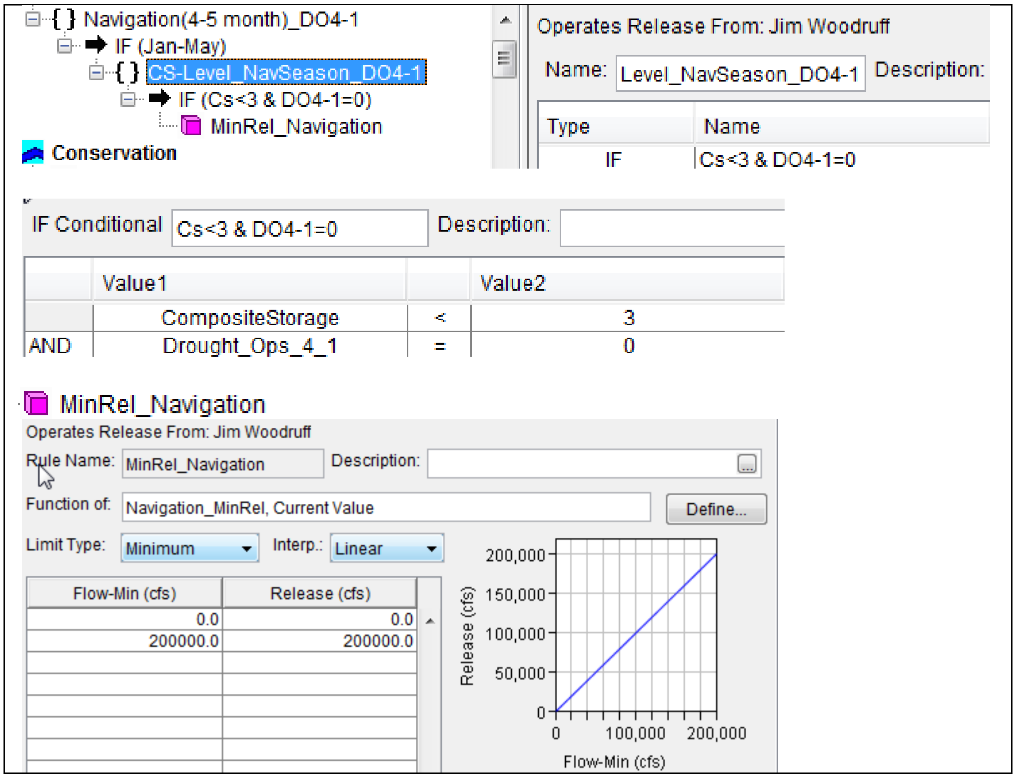


Figure K.71 Release Rules for *Navigation(4-5)month_DO4-1* Rule

2. *Suspend Ramping Rate during Prolonged Low Flow*

The Silver operation set suspends Ramping Rate required by the RIOP during prolonged low flow situation. The state variable *ProlongedLowFlows* shown in Figure K.72 is described in Appendix H. The Proloned Low Flow criteria, suspend maximum fall rates when flows have been < 7,000 cfs for 30 days, and resume when flows > 10,000 cfs for 30 days. If flow conditions are met and the state variable equals 1, then *RIOP-Falling Ramp Rate PA2* rule is used instead of *BI-Falling Ramp Rate* rule.

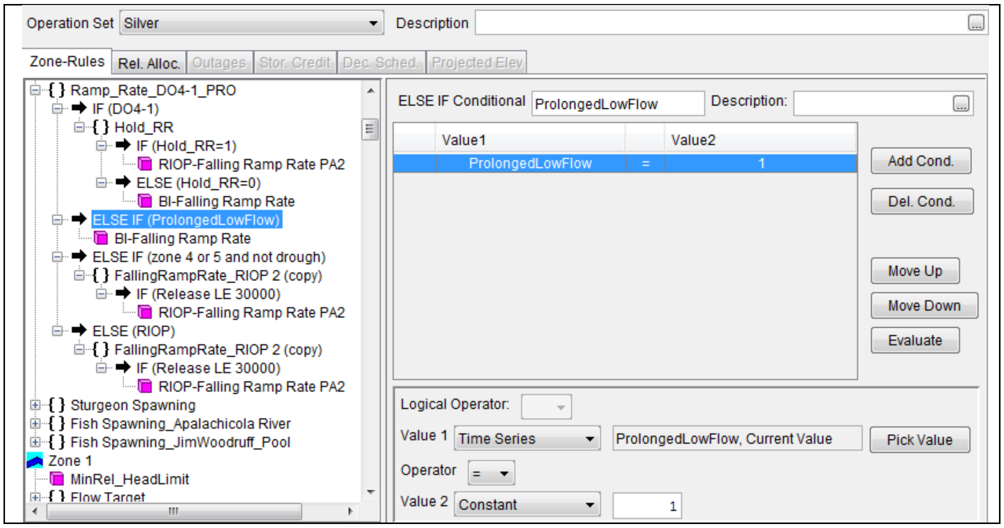


Figure K.72 Conditional Block for *Ramp_Rate_DO4-1_PRO* Rule

V. Alt3

In the **Alt3** alternative, *one project* has an operation set that is *different from the Alt2 alternative*. This project is *Jim Woodruff*. Table K.10 shows the operation sets used in the Alt3 alternative. The differences in the operation set are discussed in the following sections.

Table K.10 Operation Sets Used in Alt3 Alternative

Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	Silver	Yes
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	Silver	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	Silver	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	**Crimson**	No

A. Jim Woodruff

1. Tri-Rivers Navigation

The Crimson operation set modifies the “Flow Target” logic from the NO-Action operation set to reflect the Tri-Rivers Navigation rule. This establishes minimum outflows from Jim Woodruff as a function of season, composite storage, and basin inflow, as shown in Table K. 11**.** The operation set preserves the releases attributes of the RIOP2012 and integrate navigation support into the transition periods between average to high flows where no navigation support was necessary and moderate/low flows when augmentation from the reservoir was necessary. Two important concepts also integrate into this approach, there is a limit to the amount of augmentation which can be supported by the ACF federal reservoirs and flow target are based on no dredging occurring in the Apalachicola River. Table K.12 listed the flow requirements to provide 3 navigation depths. The 'JimWoodruff Q' column represents the Jim Woodruff estimated release required to provided the corresponding navigation depth. For example, a Jim Woodruff release of 18,800 cfs will provide the 9 ft channel depth in the Apalachicola River. This is based on a correlation of Blountstown and Chattahoochee flow data for the period 1999-2008. An augmentation amount of 3,000 cfs selected to test the concept. So if the navigation channel was to be provided a 18,800 cfs flow and the augmentation limit was 3,000 cfs then if local inflow was greater than 15,800 (18,800 - 3,000) then the model will release 18,800 to support the 9-foot channel.

Unlike the “Flow Target” logic of the NO_Action operation set, the Tri-Rivers Navigation rule applies to the flood control zone (at lesser priority than the head limits rule).

Table K. 11 Tri-Rivers Navigation Rule from Jim Woodruff Dam

Months	Composite Storage Zone	Basin Inflow(BI)(cfs)	Release from JWLD(cfs)
Mar-May	Zone 1	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 2	>=34,000	=25,000
		>=min(16,000;9ft NavQ-9ft Augmentation)	=max(16,000+50%BI>16,000;9ft NavQ+50%BI>9 ft NavQ)
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
	Zone 3	>=39,000	=25,000
		>=9ft NavQ-9ft Augmentation	= 9 ft NavQ+50%BI>9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=5,000 and <7ft NavQ- 7ft Augmentation	=BI
		<5,000	=5,000
Jun-Nov	Zones 1,2, and 3	>=22,000	=max(16,000;9ft NavQ)
		>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		>=10,000 and <7ft NavQ- 7ft Augmentation	=10,000 + 50% BI>10,000
		>=5,000 and <10,000	=BI
		<5,000	=5,000
Dec-Feb	Zones 1,2, and 3	>=9ft NavQ-9ft Augmentation	=9ft NavQ
		>=8ft NavQ-8ft Augmentation	=8 ft NavQ
		>=7ft NavQ-7ft Augmentation	=7 ft NavQ
		<7ft NavQ- 7ft Augmentation	=5,000
At all times	Zone 4	NA	=5,000(Store all BI>5,000)
At all times	Corps Exceptional Drought Trigger Zone	NA	=4,500(Store all BI>4,500)*
*Once composite storage falls below the top of the Corps Exceptional Drought Trigger Zone ramp down			
9ft NavQ = 18,800 cfs 8ft NavQ = 17,400 cfs 7ft NavQ = 16,100 cfs			

Table K.12 flow requirements to provide 3 navigation depths

Navigation Depth	Blountstown Q	JimWoodruff Q	Augmentation
9	20,600	18,800	3,000
8	18,300	17,400	3,000
7	16,200	16,100	3,000

The content of Tri-Rivers Navigation rule in the ResSim model is shown in Figure K.73 through Figure K.78.

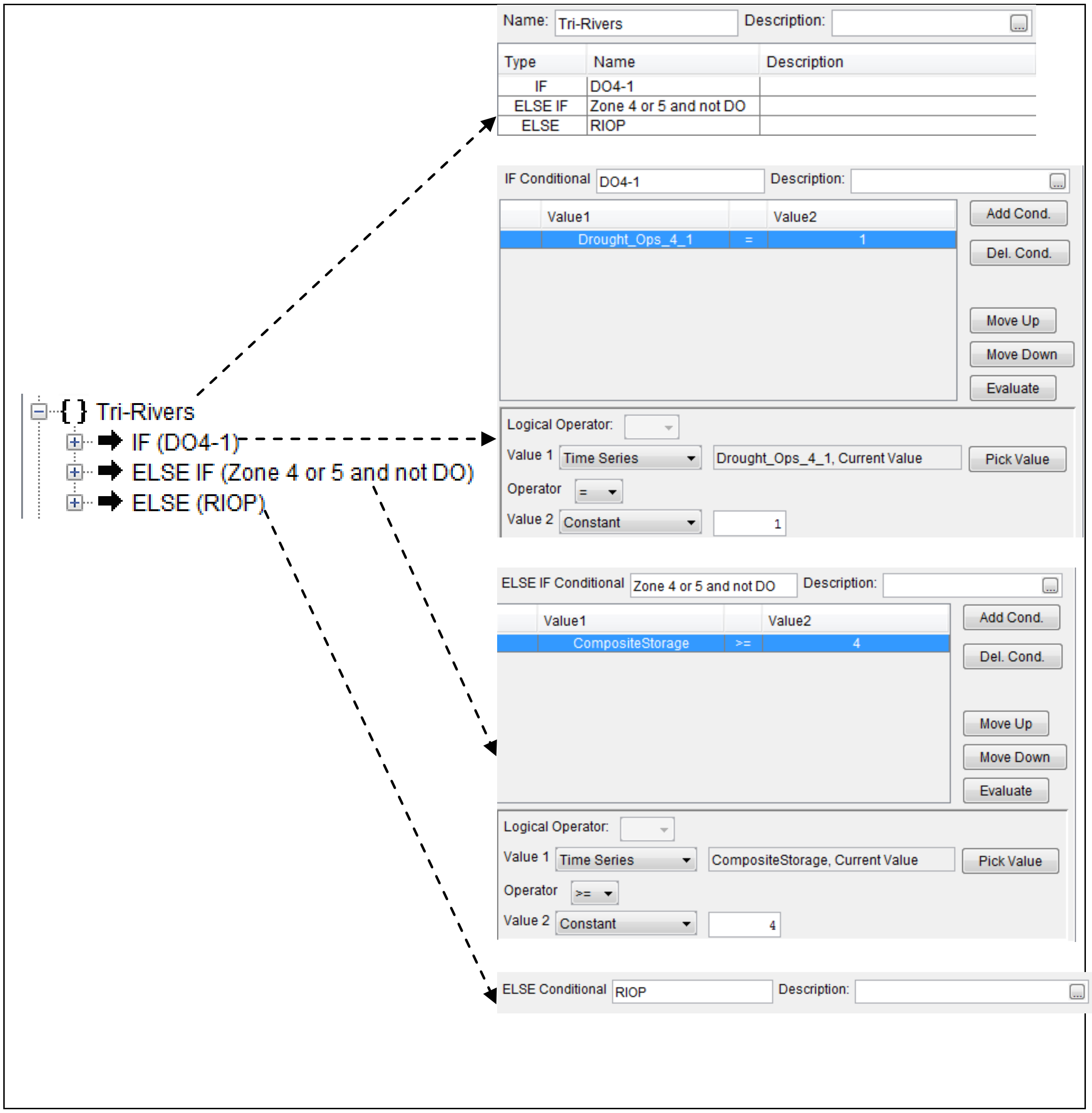


Figure K.73 Tri-Rivers (Part 1 of 6): Overview of " IF (DO4-1) - Else IF (Zone 4 or 5 and not DO) -Else (RIOP)"

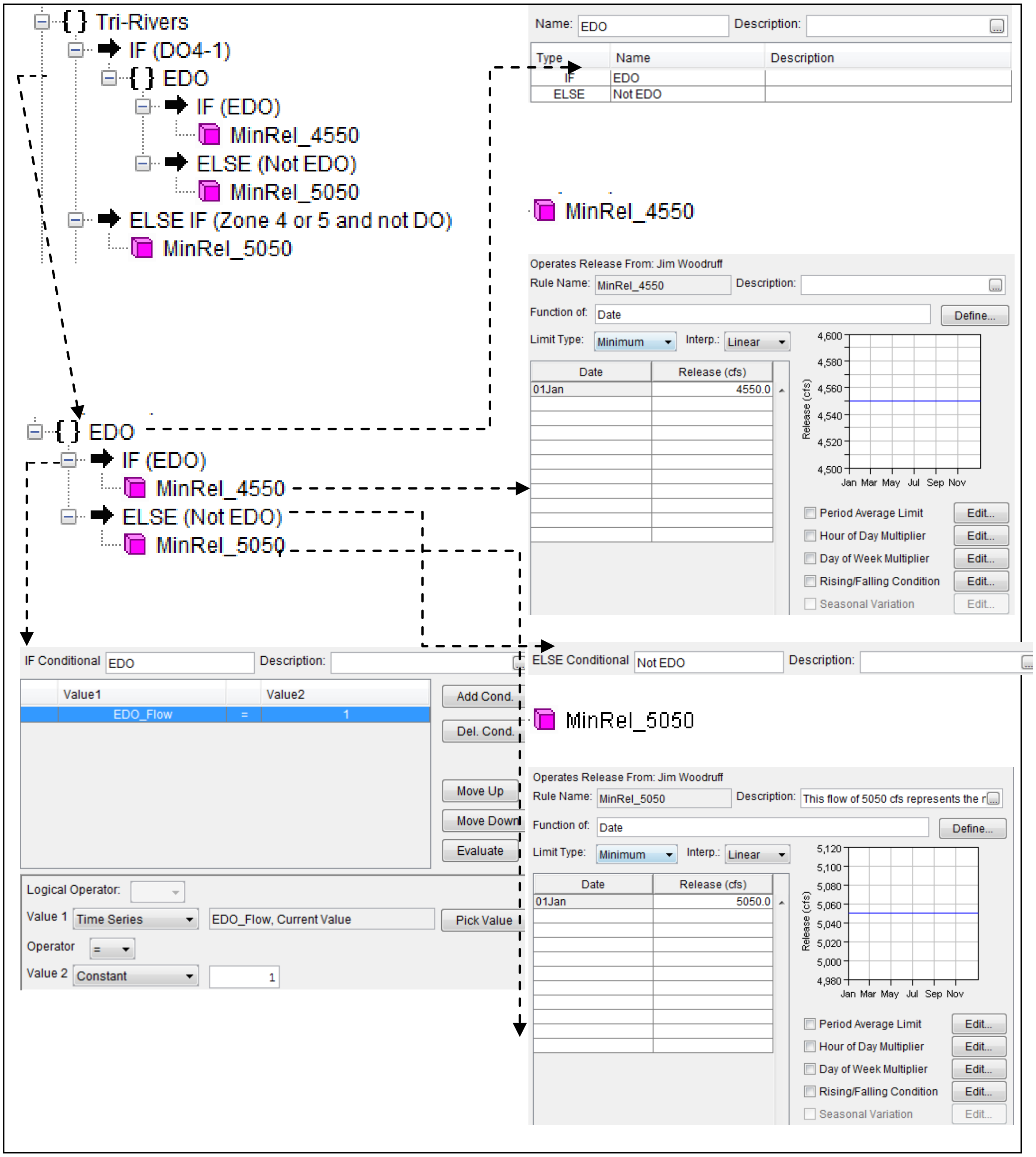


Figure K.74 Tri-Rivers *(Part 2 of 6)*: Drought Operations ,Checking for “EDO” , “MinRel_4550”and Not EDO, “MinRel_5050”

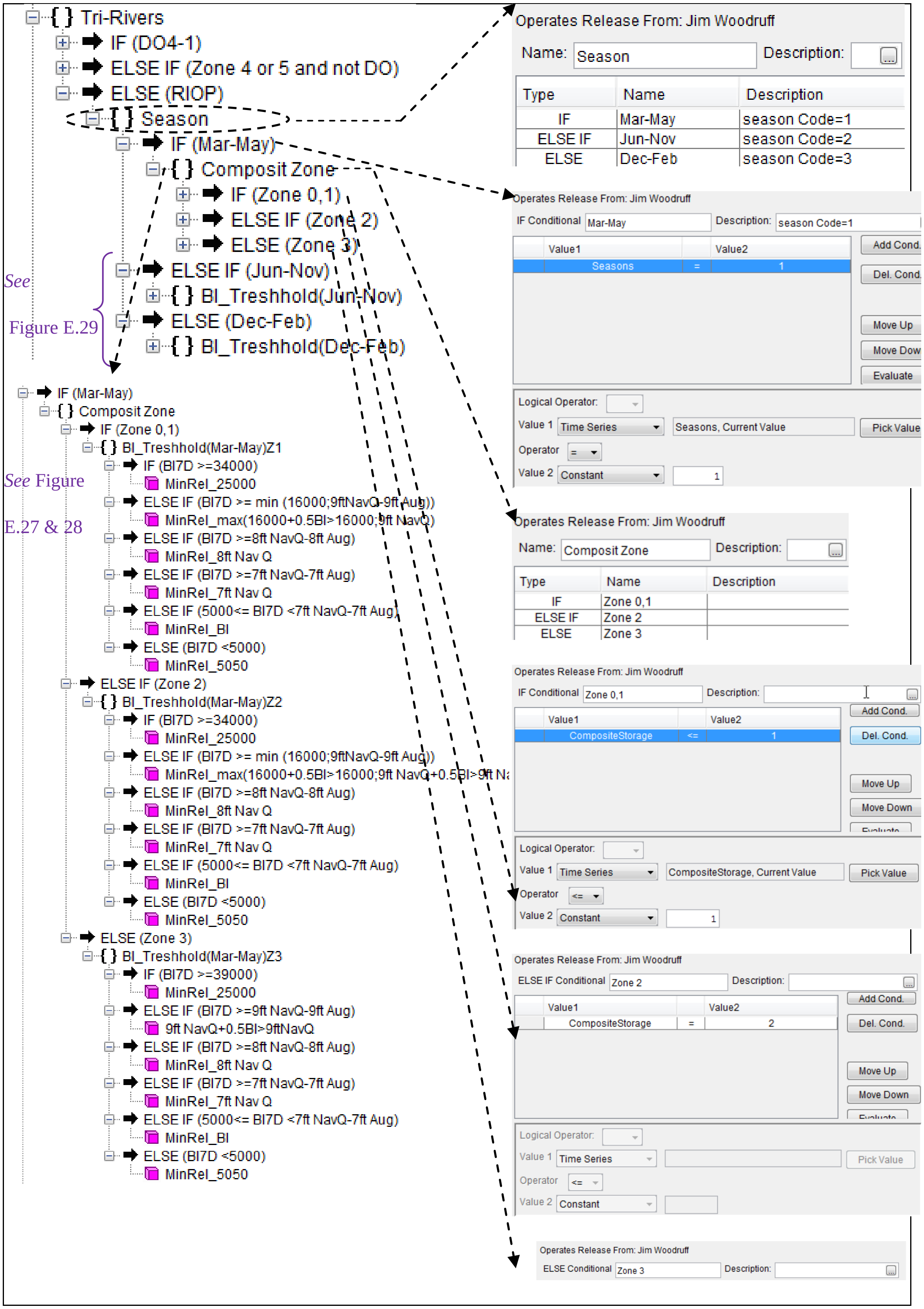


Figure K.75 Tri-Rivers (Part 3 of 6): Season– "Overview" and check for "(Mar-May)" – Part 1 of 3

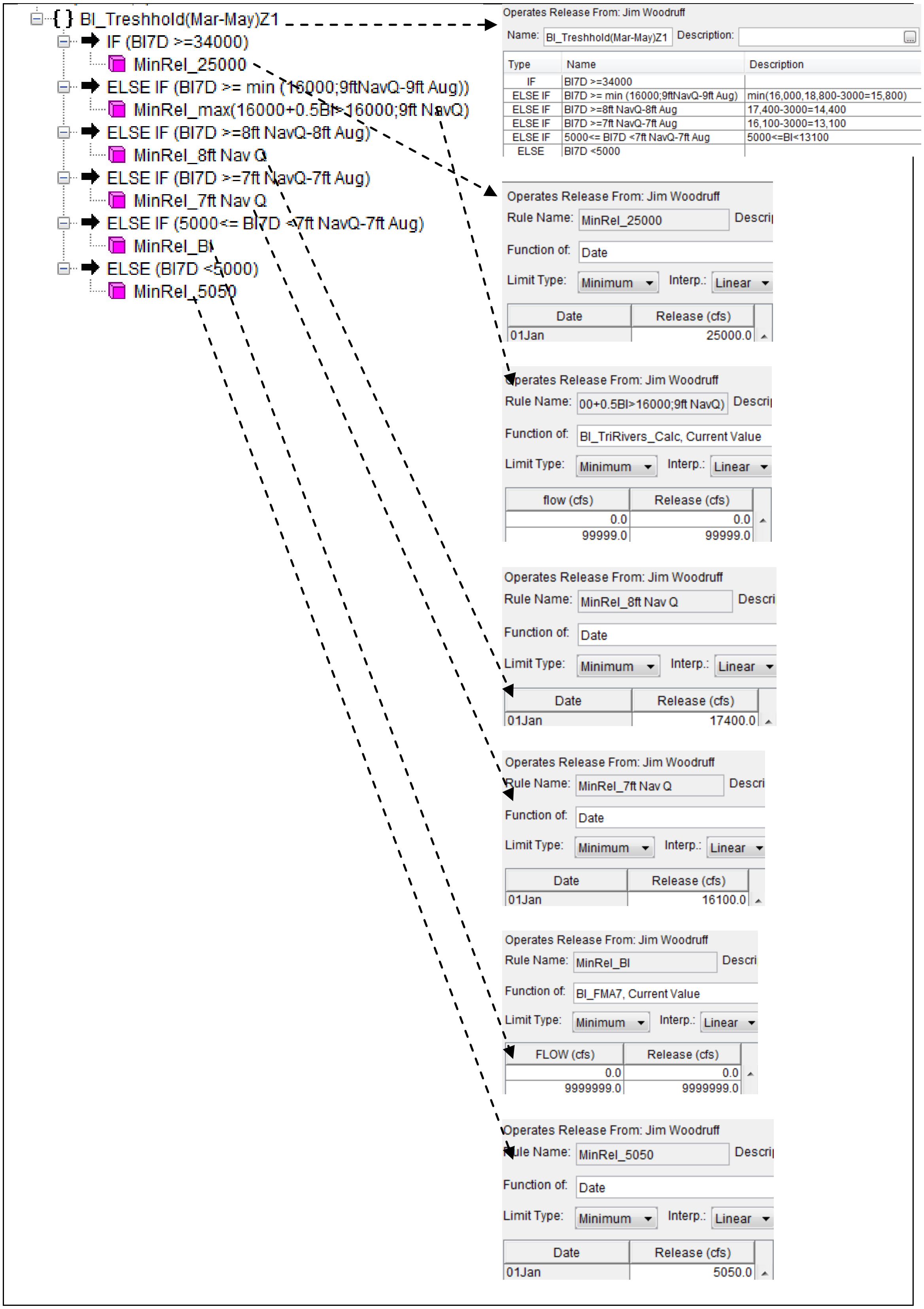


Figure K.76 Tri-Rivers (Part 4 of 6): Season– "Overview" and check for "(Mar-May)" – Part 2 of 3

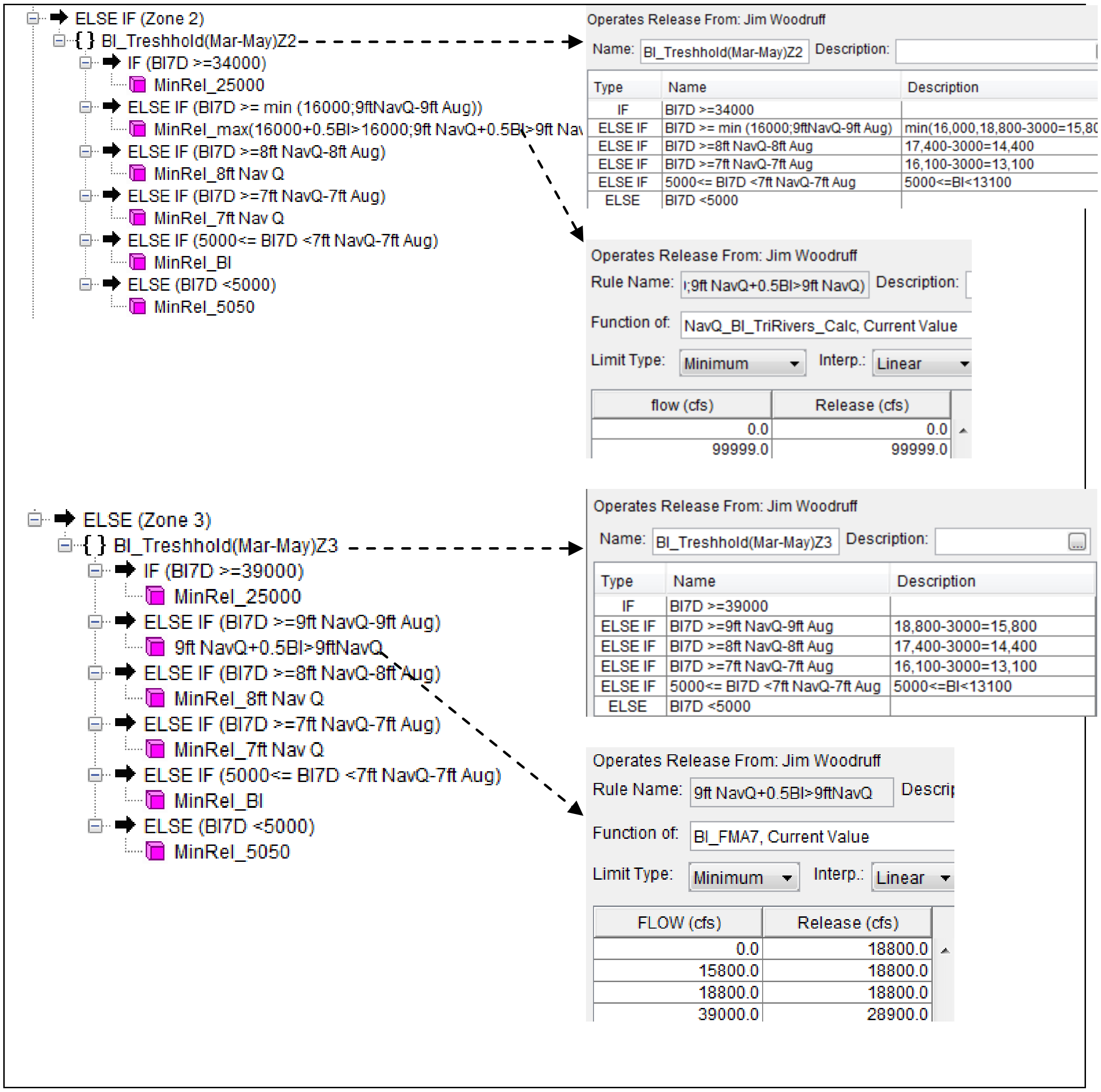


Figure K.77 Tri-Rivers (Part 5 of 6): Season– "Overview" and check for "(Mar-May)" – Part 3 of 3

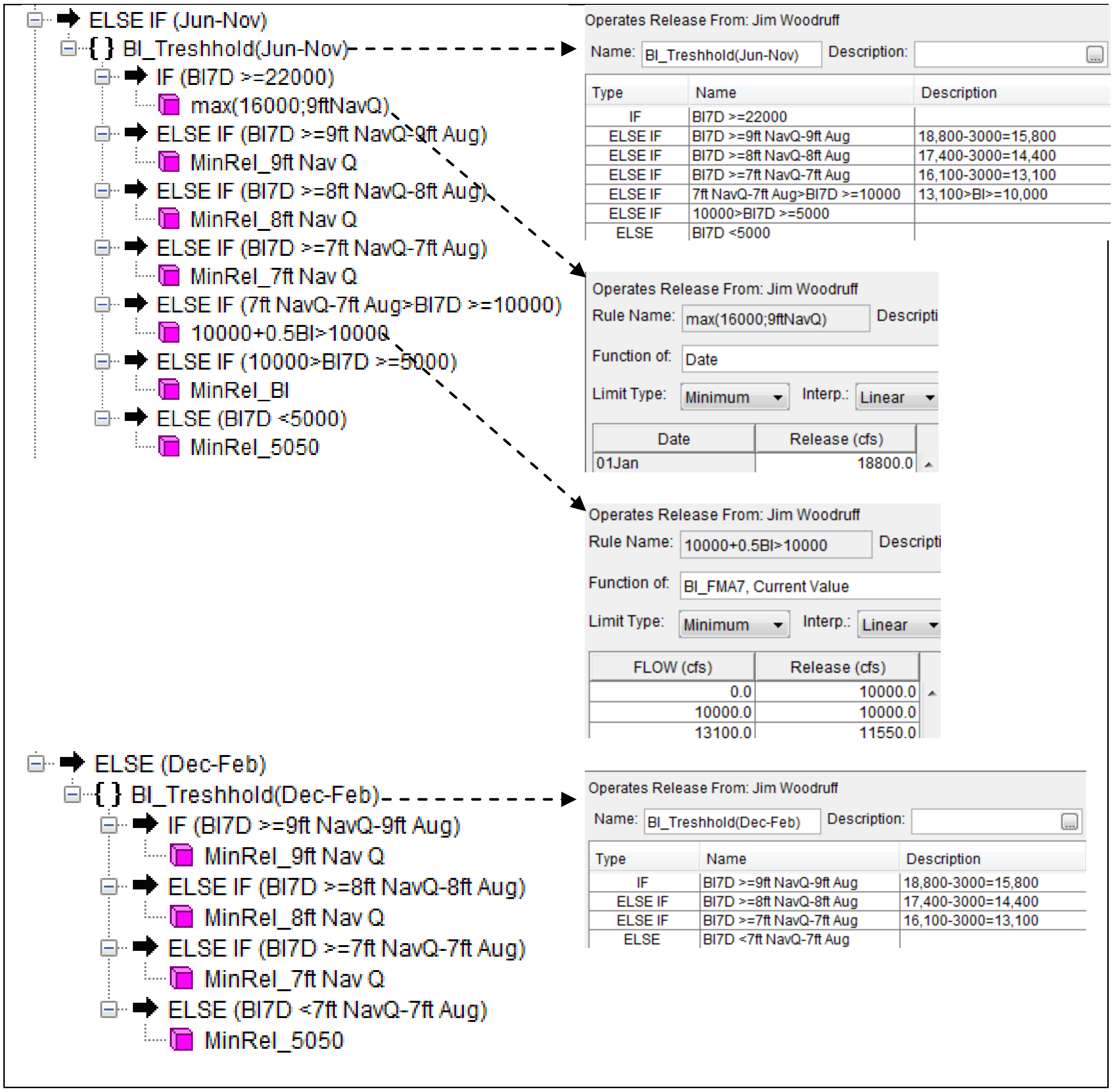


Figure K.78 Tri-Rivers (Part 6 of 6): Season– "Overview" and check for "(Jun-Nov)" and "(Dec-Feb)"

VI. Alt4

In the **Alt4** alternative, *one project* has an operation set that is *different from the Alt2 alternative*. This project is *Jim Woodruff*. Table K. 13 shows the operation sets used in the Alt4 alternative. The differences in the operation set are discussed in the following sections.

Table K. 13 Operation Sets Used in Alt4 Alternative

Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	Silver	Yes
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	Silver	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	Silver	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	**Orange**	No

A. Jim Woodruff

The Orange operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to Navigation, Florida Basin Inflow, Florida Flow Target, and Florida Ramping Rate. It also applies the MinRel_5050 rules at highest priority to the flood control zone and all conservation zones.

1. Navigation (4-5 month) _FL

The *Navigation (4-5 month) _FL* rule closely resembles the rule used in the Silver operation set, except that this version does not consider the drought state. Settings for *Navigation (4-5 month) _FL* rule are shown in Figure K.79. The state variable *NavigationSeason* defines the navigation season between January and May and *MinRel_Navigation* rule initiates the release of all incoming flow to help achieve flows 16,200 cfs at Blountstown, which provides 7 ft of navigation depth. The rule applies to the flood control zone and all conservation zones.

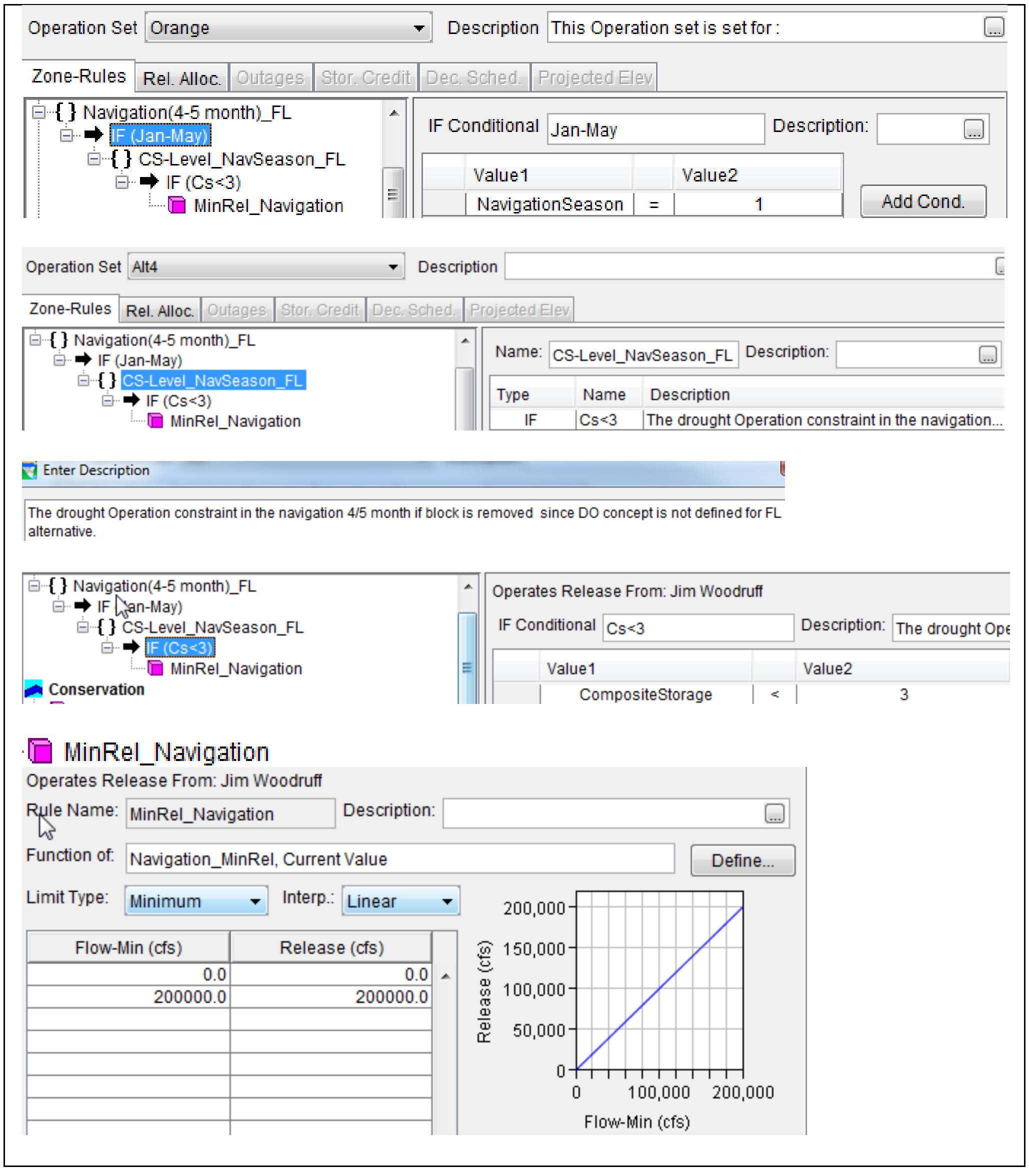


Figure K.79 Release Rules for Navigation (4-5)month_FL

2. *Florida Basin Inflow*

The RIOP method of calculating basin inflow does not consider large depletions from water consumption and reservoir evaporation. Florida proposed Revised Basin Inflow (RBI) calculation includes depletions used in the reservoir model, in order to better represent "true" basin inflow.

RBI estimates depletions according to three climatological classifications of years (Wet, Normal, and Dry), as shown in Table K. 14. Depletions used in Corps model include municipal and industrial demands, agricultural demands, and Federal reservoir evaporation which are defined for given month and type of year and shown in Table K. 15.

Table K. 14 Types of Years

1939	N	1958	W	1977	N	1996	N
1940	N	1959	N	1978	N	1997	N
1941	D	1960	N	1979	N	1998	N
1942	N	1961	N	1980	N	1999	D
1943	N	1962	N	1981	D	2000	D
1944	W	1963	N	1982	N	2001	N
1945	N	1964	W	1983	N	2002	N
1946	W	1965	W	1984	N	2003	W
1947	W	1966	N	1985	N	2004	N
1948	W	1967	N	1986	D	2005	N
1949	W	1968	D	1987	N	2006	D
1950	N	1969	N	1988	D	2007	D
1951	D	1970	N	1989	N	2008	N
1952	N	1971	W	1990	D	2009	N
1953	W	1972	N	1991	W	2010	N
1954	D	1973	W	1992	N	2011	D
1955	D	1974	N	1993	N	2012	D
1956	D	1975	W	1994	W		
1957	N	1976	N	1995	N		
W=Wet Years, N=Normal Years, D=Dry Years							

Table K. 15 Summary of depletions (cfs) to basin inflow upstream of Woodruff Dam used in Florida Basin Inflow

	Municipal and Industrial				Agriculture				Reservoir Evaporation				Total			
	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years	Dry	Normal	Wet	All Years
Jan	334	300	331	312	1	1	0	1	-183	-279	-415	-273	152	22	-85	40
Feb	302	263	295	276	23	3	0	7	-78	-159	-168	-141	246	107	127	142
Mar	345	254	257	276	94	41	31	53	153	-39	-197	-12	592	257	92	316
Apr	453	332	317	359	212	103	83	126	567	389	194	408	1231	825	594	883
May	615	457	340	480	586	344	292	395	672	573	338	569	1873	1374	970	1444
Jun	715	494	406	536	793	439	368	514	666	485	329	509	2173	1419	1104	1559
Jul	700	525	382	550	903	587	506	651	477	387	-61	356	2080	1499	827	1557
Aug	710	532	429	562	955	578	486	658	484	409	321	416	2149	1519	1236	1634
Sep	592	500	485	520	672	328	259	401	418	358	478	386	1682	1186	1222	1307
Oct	552	466	461	486	251	130	105	156	316	315	265	310	1119	912	831	951
Nov	435	378	388	392	192	90	70	112	33	-128	66	-67	660	339	525	437
Dec	399	337	358	354	168	79	62	98	-130	-186	-63	-158	437	230	356	293
Average	514	404	371	426	406	228	180	266	284	179	91	193	1204	811	652	885

3. Florida Flow Target

The operational requirements for Florida alternative is represented in Table K. 16. The *Florida Flow Target* rule establishes minimum outflows from Jim Woodruff as a function of composite storage, and basin inflow. The objective is to get Chattahoochee flows as close as possible to natural flows. The release trigger based on RBI instead of current Basin Inflow that includes net consumption in the basin above Jim Woodruff. A set of daily minimum flow are based on historic exceedance values that vary with season, composite storage zone and inflow conditions; dry or normal/wet. An additional release amount of 50% of available RBI over the minimum release is added to the minimum. Additional releases are not required when composite storage is in the drought zone (still under development at the time public comments were received). There are no additional rules for minimum flow reductions during drought operations. Minimum flows are simply lower for lower composite storage zones. When composite storage is in higher zone, minimum flows are higher.

Table K. 16 Florida Flow Target

<table>
<tr><th rowspan="2">If Composite Conservation Storage-P7 is:</th><th rowspan="2">And if RBI-P7 is in:</th><th colspan="2">The average flow release-U7 is:</th></tr>
<tr><th>Minimum Flow</th><th>Plus additional Flow</th></tr>
<tr><td rowspan="2">Zone 1 or 2</td><td>Mid to High range</td><td>80% exceedance-U7</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td>Low range</td><td>85% exceedance-U7</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td rowspan="2">Zone 3 or 4</td><td>Mid to High range</td><td>90% exceedance-U7 with a minimum of 6,000 cfs</td><td>50% of any RBI-P7 that exceeds minimum flow</td></tr>
<tr><td>Low range</td><td>95% exceedance-U7 with a minimum of 5,000 cfs</td><td>Mar-Nov: 50% of any RBI-P7 that exceeds minimum flow
Dec-Feb: No additional release required.</td></tr>
<tr><td>EDO</td><td>All Conditions</td><td>99% exceedance-U7 with a minimum of 5,000 cfs</td><td>No additional release required except 50% of storm pulses under certain conditions*</td></tr>
<tr><td colspan="4">*Conditions when 50% of storm pulses are released are under review and will be include at a later time.

Terms: P7=for the last seven days;U7=for the upcoming 7 days; RBI= revised Basin Inflow
Mid to High range=>75% exceedance of 7-day rolling average unimpaired flow(1939-2008);
Low range=<75% exceedance of 7-day rolling average unimpaired flow(1939-2008)</td></tr>
</table>

The RBI-P7 is classified as ‘Mid to high range’ or ‘Low range’. The 75% exceedance of the 7-day rolling average unimpaired flow (1939-2008) is used as the threshold; if greater than ‘Mid to high range’ if less than ‘Low range’. The daily flow range criteria is shown in Figure K.80.

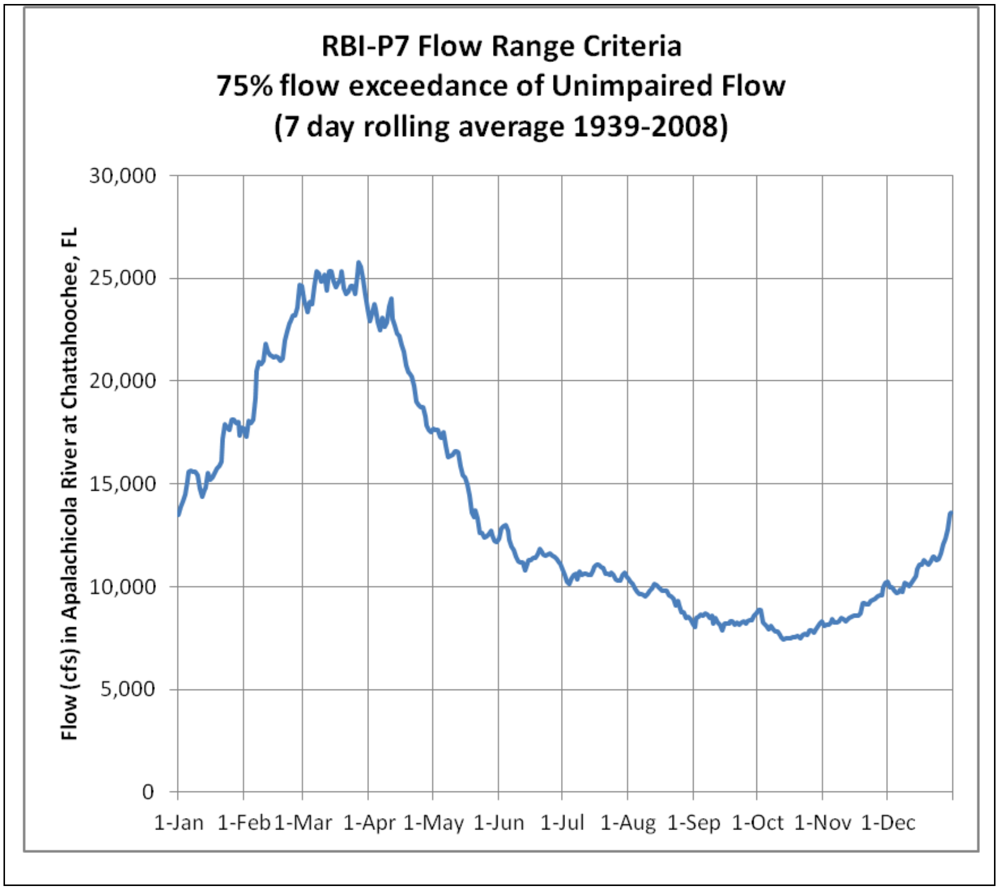


Figure K.80 Florida Flow Target-Flow range criteria

The set of minimum daily flows based on historic exceedance values are as follows;

80% exceedance pre-Buford Dam 1923-1955
85% exceedance pre-Buford Dam 1923-1955
90% exceedance pre-West Point Dam 1975-2008 (with 6,000 cfs min)
95% exceedance pre-West Point Dam 1975-2008 (with 5,000 cfs min)
99% exceedance pre-West Point Dam 1975-2008 (with 5,000 cfs min)

The daily minimum values are shown in Figure K.81.

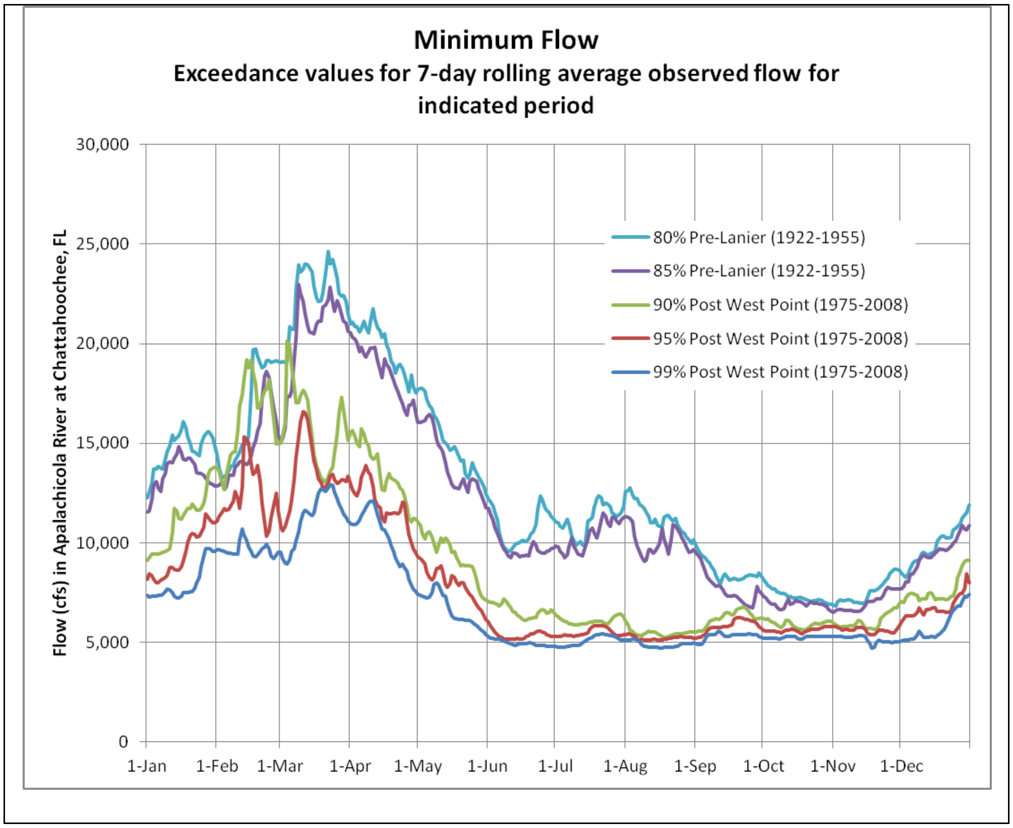


Figure K.81 Florida Flow Target-Daily Minimum Flow

4. Florida Ramping Rate

Table K. 17 shows the proposed ramping rate for Orange operation set for flows <30,000 and > 8,000 more restrictive when compared to NoAction RIOP-Falling Ramp Rate PA2 rule. Fall rate for flows in excess of power capacity up to 30,000 cfs restricted to 0.5 ft/day. Fall rate for flows in range of 8,000 to 16,000 cfs restricted to 0.25 - 0.5 ft/day. Ramping rate of 0.25 ft/day will continue while in Zone 4 and in Extreme Drought Operations Zone. There will be no suspension of ramping rates under any conditions.

Table K. 17 Florida Ramping Rate

Flow range (cfs)	Maximum fall rate (ft/day)
>30,000	No ramping restriction
Exceeds powerhouse capacity(~16,000) and <=30,000*	0.5
Within powerhouse capacity(16,000) and >8,000*	0.25 to 0.5
Within powerhouse capacity(16,000) and <=8,000*	0.25
*Including implementation in CCS Zone 4	

The *Florida Ramping Rate* rule applies in the conservation zones, at priority less than *Navigation (4-5 month) _FL.*

VII. Alt5

In the **Alt5** alternative, *one project* has an operation set that is *different from the Alt2 alternative*. This project is *Jim Woodruff*. Table K. 18 shows the operation sets used in the Alt5 alternative. The differences in the operation set are discussed in the following sections.

Table K. 18 Operation Sets Used in Alt5 Alternative

Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	Silver	Yes
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	Silver	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	Silver	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	**Peach**	No

A. Jim Woodruff

The Peach operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to Navigation, Georgia Basin Inflow, Georgia Flow Target, and Suspend Ramping Rate after Pulse Flow.

1. Navigation (4-5 month) _DO4-1

Navigation operation rules were added to the current operation set, to model the feasibility of a five month navigation season from January through May. This operation rule is the same as Alternative 2 and is described in Figure K.70 and Figure K.71.

2. *Georgia Basin Inflow*

Basin inflow is defined the same as NO-Action for Georgia alternative except that it does not consider the lagging in the basin inflow computation. The formula provided is listed below:

> Basin Inflow = Chattahoochee River flow + Lanier change in storage + West Point change in storage + WF George change in storage + Jim Woodruff change in storage

3. *Georgia Flow Target*

The operational requirements for Georgia alternative is represented in Table K. 19. The *Georgia Flow Target* rule establishes minimum outflows from Jim Woodruff as a function of month, composite storage, and basin inflow. The intent of the release rules are to

- Target the highest amount of sustainable spawning habitat with the most economic use of storage
- Target the best availability of sustainable flood plain connectivity the Gulf sturgeon spawning period (March-May)
- Link the amount of preferred mussel habitat with stage and flow by using the Corps' bathymetric data of the Apalachicola River
- Design release rules to maximize the amount of mussel habitat

Table K. 19 Georgia Flow Target

Months	Total storage in Reservoirs	Basin Inflow(BI) (cfs) or other conditions	State Line Flow (SLF) (cfs)	Basin Inflow to be stored (cfs)
March	Zone 1,2, and 3	NA	>=6,500	Entire or partial BI above SLF, subject to available Storage capacity
April 1-May 31	Zone 1,2, and 3	Cumulative BI in February and March > 2.45 million acre-feet	Maintain Q=min(10,500, min(observed moving 30-day flow))	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if BI>=10,500	>= 10,500	
		If BI<10,500 and >= 5,000	>= BI	
		If BI <5,000	>= 5,000	
In sub-period April 16-April 30		Lanier>1066' , and West Point>632' , and Walter F George >187'	Maintain Q=min(22,500,max(10,500, min(observed March 17-April 15 daily flow)))	Entire or partial BI above SLF, subject to available Storage capacity
June-Nov	Zone 1,2, and 3	BI>= 10476 & previous seven day's Chattahoochee gage flow<5100	>= High Pulse flow (June 14,850, July 15,500, August 14,400, September 11,200, October 10,100, November 10,500), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		BI>= 7181 and < 10476 & previous seven day's Chattahoochee gage flow<5100	>= Small Pulse flow (June 11,600, July 11,500, August 11,100, September 8,620, October 7,420, November 7,980), No rise & fall rate limit	Entire or partial BI above SLF, subject to available Storage capacity
		Other Situation	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4 Or Drought Ops	NA	>=5,000	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	>=4,500	Entire or partial BI above 5,000 subject to available Storage capacity

The following is a detailed description of the flow target by season.

March 1 through March 31

Georgia Flow Target maintains a minimum flow requirement in the Apalachicola River at Chattahoochee, Florida for March of 6,500 cfs. March historically has been the wettest month in the ACF Basin, and monthly average flow in the Apalachicola River at the Chattahoochee gage during March is expected to exceed 6,500 cfs.

April 1 through May 31

Conserve system storage to meet water supply and other authorized reservoir purpose the observation of February and March flow provides a good basis for determining subsequent flow and a sustainable level of spawning season habitat. Georgia Flow Target use cumulative February and March basin inflow (BI) to determine if the ACF Basin is likely to be under drought conditions. When cumulative BI for February and March is higher than 2.45 million acre-feet, the basin is considered to be under normal spring hydrologic conditions. When cumulative BI is lower than 2.45 million acre-feet, the basin is likely to be either in drought or approaching drought conditions. When the basin is under normal spring hydrologic conditions, we set release into the Apalachicola River at the lower of 10,500 cfs or the moving minimum of the previous 30 days. A 10,500 cfs flow provides about 85% of all the available sturgeon spawning habitat at the amount of inundation specified in the 2012 Biological Opinion. When the basin is under likely drought conditions, as determined by the cumulative BI, release into the Apalachicola River is set at 10,500 cfs when BI is higher than 10,500 cfs, or BI if it is lower than 10,500 cfs, but not lower than 5,000 cfs. This assures that a continuous 30-day inundation of a large portion of the spawning habitat is achieved.

Sub-period April 16 through April 30

1. When Lanier elevation is above 1066 feet, West Point elevation is above 632 feet, and Walter F. George is above 187 feet, the Georgia Contemplation uses the following procedure to determine releases to support flood plain connectivity:

a. Determine the minimum level of flow that has been sustained in the previous 30 days

(March 17 through April 15);

b. Compare this sustained flow with 10,500 cfs, and take the larger one; and c. Compare the flow obtained in step b with 22,500 cfs, and take the lower one as the level of flow to be sustained for the sub-period.

2. When Lanier, West Point, or Walter F. George is below the elevation levels specified above, the above support of flood plain connectivity will not be provided.

This approach makes good use of naturally-higher flow in the first half of April and provides limited support from storage in the second half of April to achieve sustainable flow support for flood plain connectivity for up to 30 days

June 1 through November 30

The Georgia Flow Target maintains a 5,000 cfs minimum flow requirement as the base flow for the non-spawning season. When BI rises above the 25th percentile for the period, roughly 7,200 cfs, a pulse flow lasting one day and corresponding to the 25th percentile daily flow can be made. Table K.20 shows the values for Georgia Low Pulse Flow.

Table K.20 Georgia Low Pulse Flow

Month	25th Percentile Flow Pulse (cfs)
June	11600
July	11500
August	11100
September	8620
October	7420
November	7980

When BI rises above median for the period, roughly 10,500 cfs, the Georgia Flow Target could provide a pulse flow lasting one day and corresponding to median daily flow. Table K.21 shows the values for Georgia Low Pulse Flow.

Table K.21 Georgia High Pulse Flow

Month	Median Flow Pulse (cfs)
June	14850
July	15500
August	14400
September	11200
October	10100
November	10100

FWS has mentioned benefits of having pulse flows in the non-spawning season (June through November), including elevating dissolved oxygen, removing debris, and providing food sources to living organisms. This 1-day pulse flow attempts to provide such benefit.

Using one-day BI better enables triggering of higher pulses than 7-day average BI with an interval of seven days between any two consecutive pulses. A second pulse flow would not take place until seven days after the previous one and the 1-day BI meets the above stated conditions,

December 1 through February 28

The Georgia Flow Target only minimum flow requirement in the Apalachicola River at the Chattahoochee gage is 5,000 cfs. Any BI beyond this minimum flow requirement is stored to replenish system storage, to the extent possible.

4. *Suspend Ramping Rate after Pulse Flow*

The Peach operation set suspends Ramping Rate after pulse flow. The state variable *Pulse* is shown in Figure K.82.This state variable is described in Appendix H. If flow conditions are met and the state variable equals 1, then *RIOP-Falling Ramp Rate* rule is suspended and *BI-Falling Ramp Rate* rule is triggered.

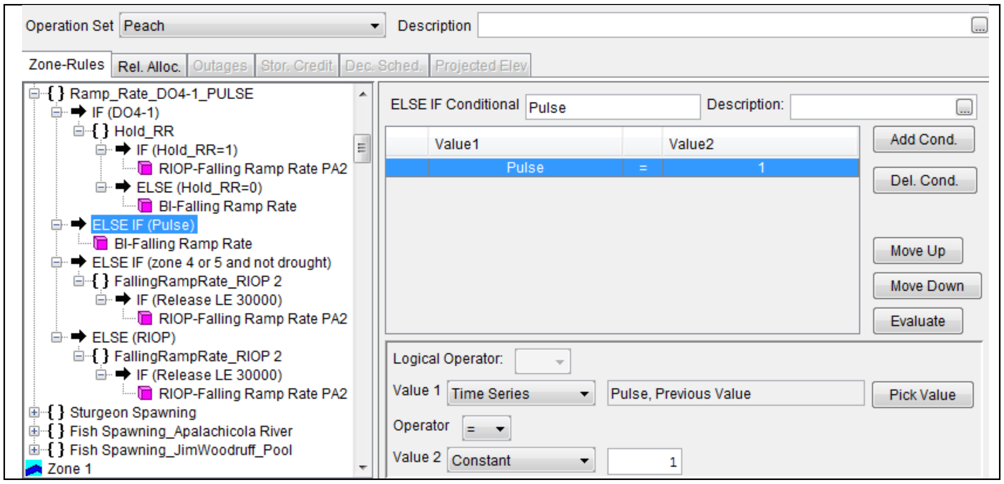


Figure K.82 Conditional Block for Ramp_Rate_DO4-1_PULSE Rule

5. Minimum Release Based on EDO

The Peach operation set applies its own version of the RIOP minimum release, called "*MinRel5050_fn_EDO*", at highest priority to the flood control zone and all conservation zones.

VIII. Alt6

In the **Alt6** alternative, *two projects* have an operation set that is *different from the Alt2 alternative*. These projects are *Buford, and Jim Woodruff*. Table K. 22 shows the operation sets used in the Alt6 alternative. The differences in the operation sets are discussed in the following sections.

Table K. 22 Operation Sets Used in Alt6 Alternative

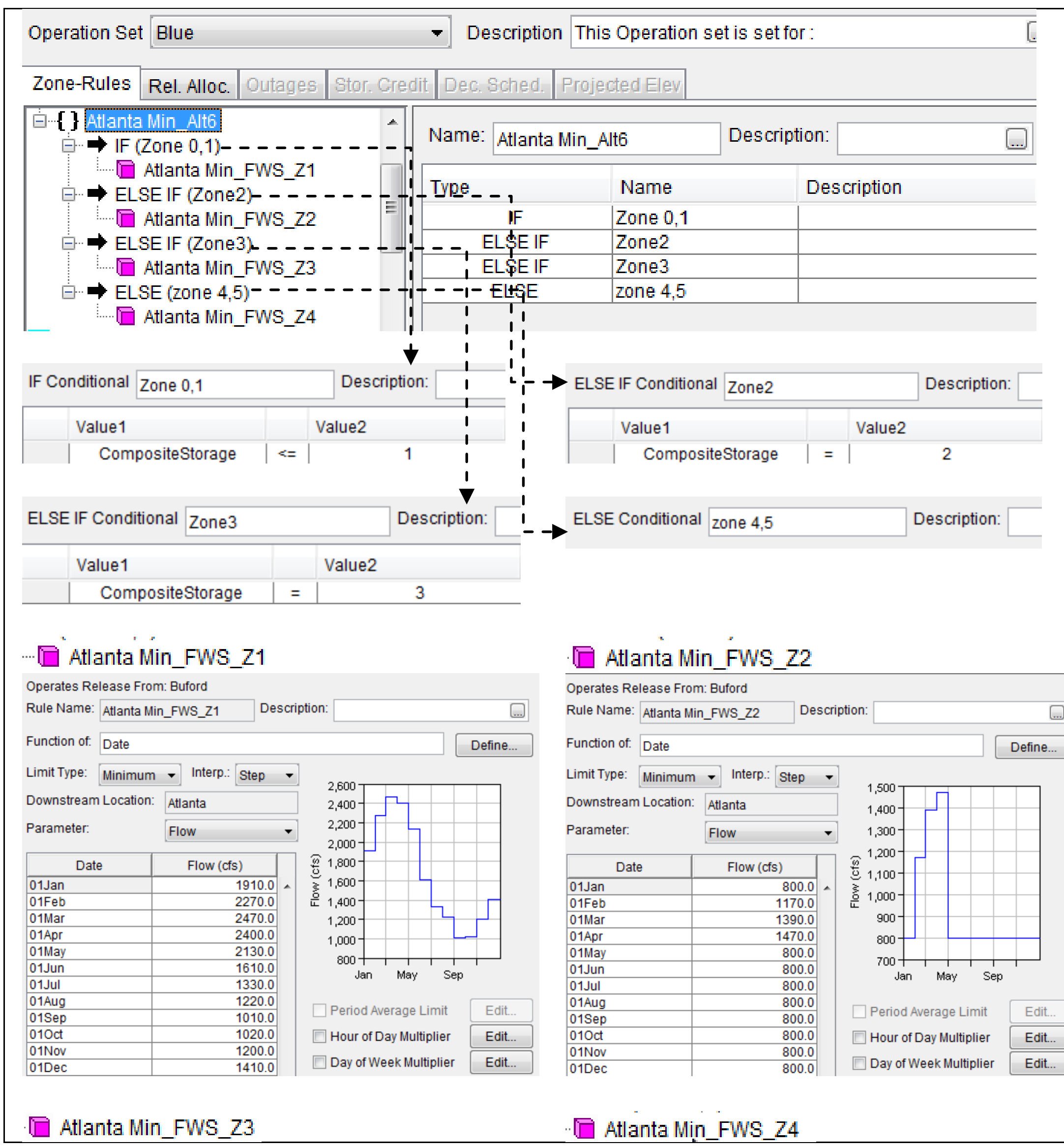
Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	**Blue**	No
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	Silver	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	Silver	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	**Blue**	No

A. Buford

The Blue operation set for Buford retains all the rules and settings from NO-Action operation set except that it uses different elevation of action zones labeled as *Revised* Action Zones, and Monthly Minimum Flow at Peach Tree Creek. The revised action zones are described in Table K.07 and Figure K.62.

1. Monthly Minimum Flow at Peach Tree Creek

The Blue operation set modifies the minimum flow rule at Peach Tree Creek to implement monthly rules to provide a minimum water quality flow in Chattahoochee just upstream from the junction with Peachtree Creek. The composite storage of the system (i.e., state variable CompositeStorage) determines which of four monthly flow patterns apply. This minimum flow rule is implemented identically to each Buford Zone above Operating Inactive, and is described in Figure K.83.



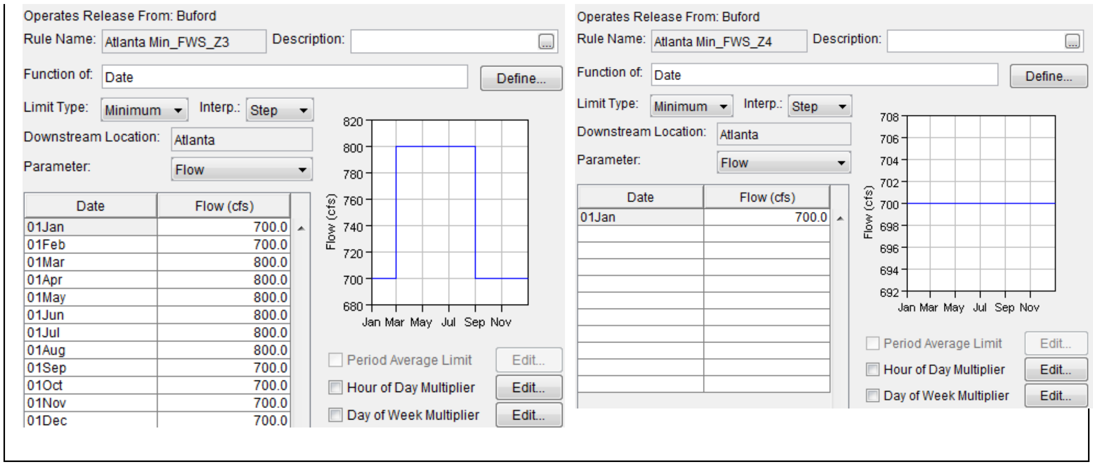


Figure K.83 Alternative 6 Operation Set Monthly Minimum Flow rule at Peach Tree Creek

B. Jim Woodruff

The Blue operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to Navigation, FWS Flow Target, and Suspend Drought Operation at Zone 3.

1. Navigation (4-5) month_DO4-3

The "*Navigation(4-5 month)_DO4-3*" rule closely resembles the navigation rule from the Silver operation set, except using a different definition of the drought condition (i.e., drought condition lifted at composite storage level 3). This revised drought condition is represented by state variable Drought_Ops_4_3, as described in Append H. . The description of *Navigation(4-5) month_DO4-3* is shown in Figure K.84.

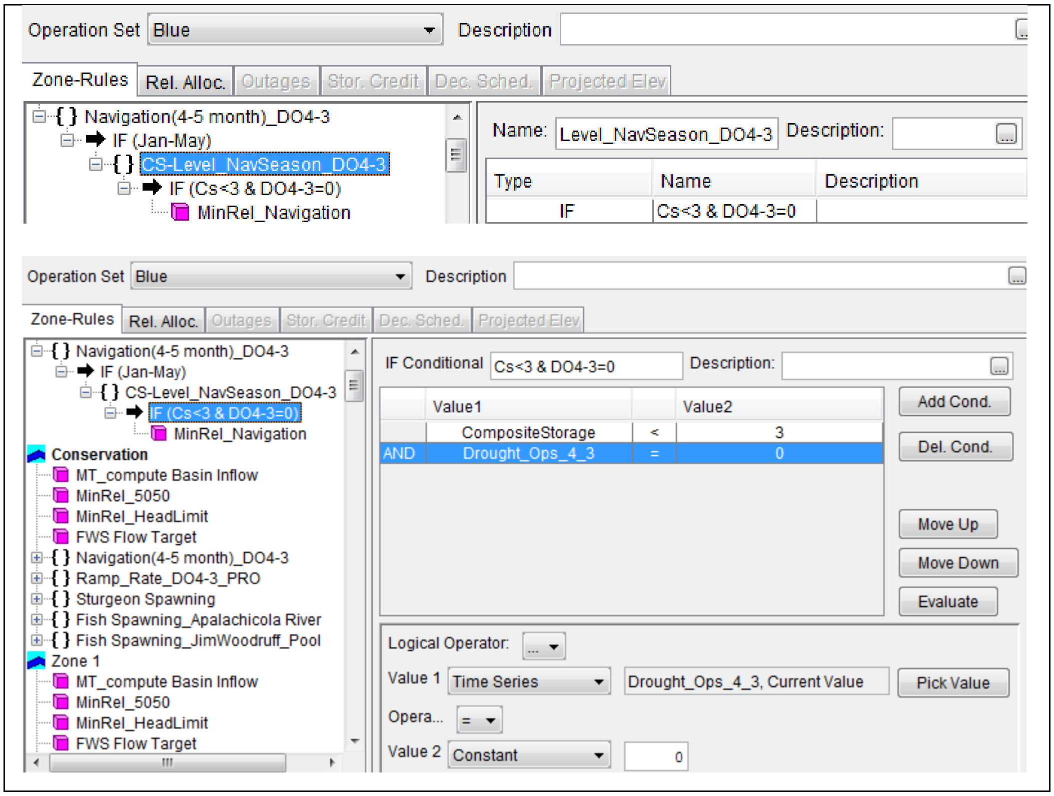


Figure K.84 Release Rules for Navigation (4-5)month_DO4-3

2. *FWS Flow Target*

The operational requirements for FWS alternative is represented in Figure K.85. The intent of the release rules are to

- Provide a reasonable degree of flow support into the Apalachicola River for the fish and wildlife purpose of the ACF projects at levels greater than 5,000 cfs.
- Minimize the number of periods per year of low flows (<10,000 cfs), which directly adversely affect fish and wildlife or otherwise limit their populations.
- Maximize floodplain connectivity, especially in the spring spawning season

If 7-day basin inflow exceeds the month/zone target, releases the target flow from Jim Woodruff dam. All basin inflow exceeding the target is available for storage, subject to flood control roles. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Jim Woodruff dam is the greater of a.) the month/zone minimum or b.) basin inflow plus the zone augmentation.

The objective is operate the system as a whole for target and minimum releases from Woodruff Dam, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates.   Target and minimum flows are month and zone-specific. Target flows are subject to zone-specific augmentation limits. Action Zones, 1 through 4, are defined for Lanier, West Point, and George, relative to the authorized top and bottom of the conservation pool. Release decisions for the system as a whole (i.e., from Woodruff Dam) are based on the current composite storage zone, month, and the previous 7-day basin inflow. Each project makes daily releases to meet local operating requirements or to replenish storage in the next project downstream, whichever is greater, so that all projects remain in the same operating zone.

FWS Target Flows, Augmentation Limits, and Minimum Flows are represented in Table K. 23, Table K. 24, and Table K. 25 respectively. The FWS flow target rule applies in the conservation zones, at a priority lower than headlimnits release, but higher than prolonged flow ramp rate.

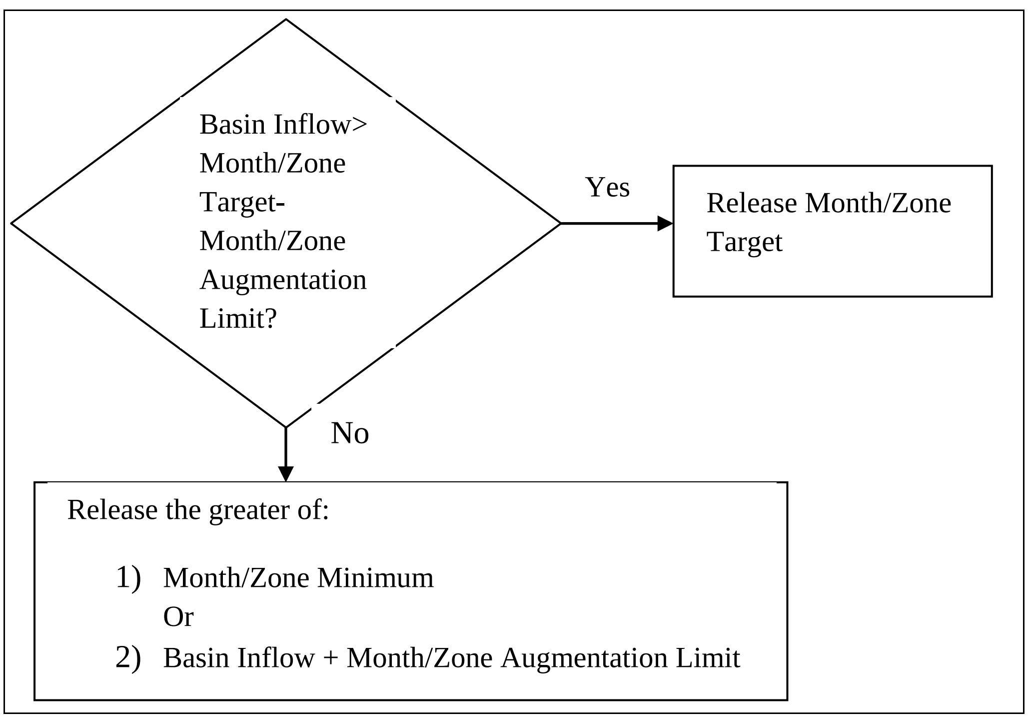


Figure K.85 FWS Flow Target

Table K. 23 FWS Target Flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	19,000	17,000	10,000	5,000
Feb	21,000	19,000	10,000	5,000
Mar	21,000	19,000	14,000	5,000
Apr	21,000	19,000	14,000	5,000
May	19,000	17,000	10,000	5,000
Jun	14,000	14,000	10,000	5,000
Jul	12,000	10,000	10,000	5,000
Aug	12,000	10,000	10,000	5,000
Sep	10,000	10,000	10,000	5,000
Oct	10,000	10,000	10,000	5,000
Nov	10,000	10,000	10,000	5,000
Dec	10,000	10,000	10,000	5,000

Table K. 24 FWS Augmentation Limits (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	2,000	0	1,000	0
Feb	4,000	2,000	2,000	0
Mar	4,000	2,000	3,000	0
Apr	4,000	2,000	3,000	0
May	2,000	4,000	2,000	0
Jun	2,000	2,000	1,000	0
Jul	2,000	2,000	1,000	0
Aug	2,000	2,000	1,000	0
Sep	0	1,500	1,000	0
Oct	0	1,500	1,000	0
Nov	0	1,500	1,000	0
Dec	0	1,500	1,000	0

Table K. 25 FWS Minimum flows (cfs) for Apalachicola River at Jim Woodruff dam

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	17,000	17,000	5,000	5,000
Feb	17,000	17,000	5,000	5,000
Mar	17,000	17,000	8,000	5,000
Apr	17,000	17,000	8,000	5,000
May	17,000	10,000	8,000	5,000
Jun	12,000	8,000	5,000	5,000
Jul	10,000	7,000	5,000	5,000
Aug	10,000	7,000	5,000	5,000
Sep	10,000	6,000	5,000	5,000
Oct	10,000	5,000	5,000	5,000
Nov	10,000	6,000	5,000	5,000
Dec	10,000	8,000	5,000	5,000

3. Suspend Drought Operations at Zone 3

Drought operation definition is the same as NO-Action except the drought plan is suspended when the composite storage reaches a level above the top of Zone 4 (i.e., within Zone 3) as shown in Figure K.86. Note that composite storages are defined based on Revised Action Zones.

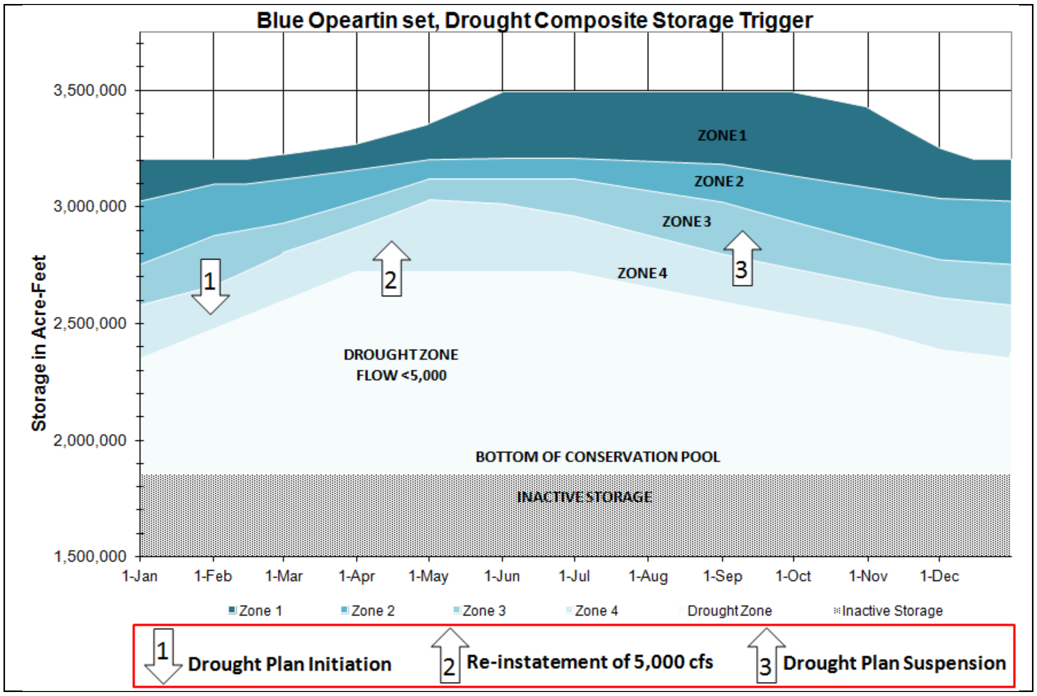


Figure K.86 Alternative 6-Drought Composite Storage Triggers

IX. Alt7

In the **Alt7** alternative, *two projects* have an operation set that is *different from the Alt2 alternative*. These projects are *Buford, and Jim Woodruff*. Table K. 26 shows the operation sets used in the Alt7 alternative. The differences in the operation sets are discussed in the following sections.

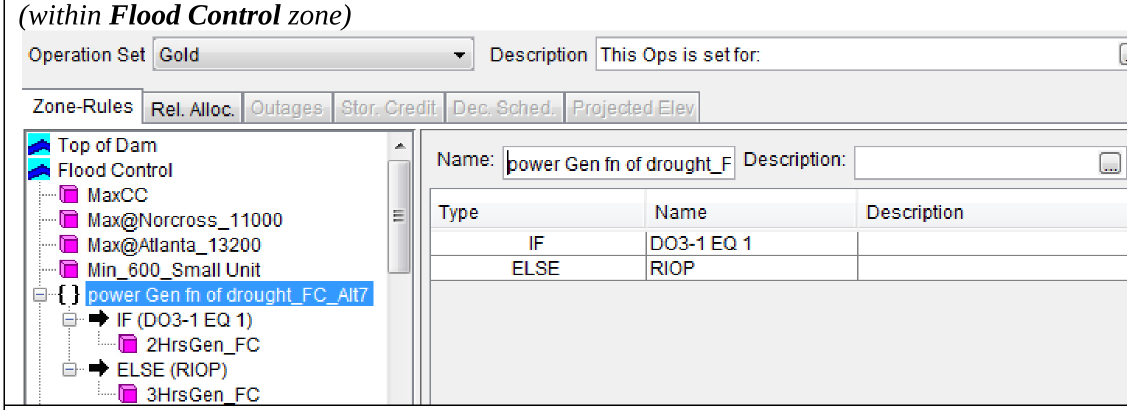
Table K. 26 Operation Sets Used in Alt7 Alternative

Project	Operation Set	Described Previously
Glades	NO-Action	Yes
Buford	**Gold**	No
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
West Point	Silver	Yes
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
Walter F George	Silver	Yes
George Andrews	Flow-thru	Yes
Jim Woodruff	**Gold**	No

A. Buford

The Gold operation set for Buford retains all the rules and settings from Silver operation set except that it triggers drought operation at zone 3 which affects hydropower rule description. These rules are shown in Figure K.87.

*(within **Flood Control** zone)*



*(within **Conservation** zone)*

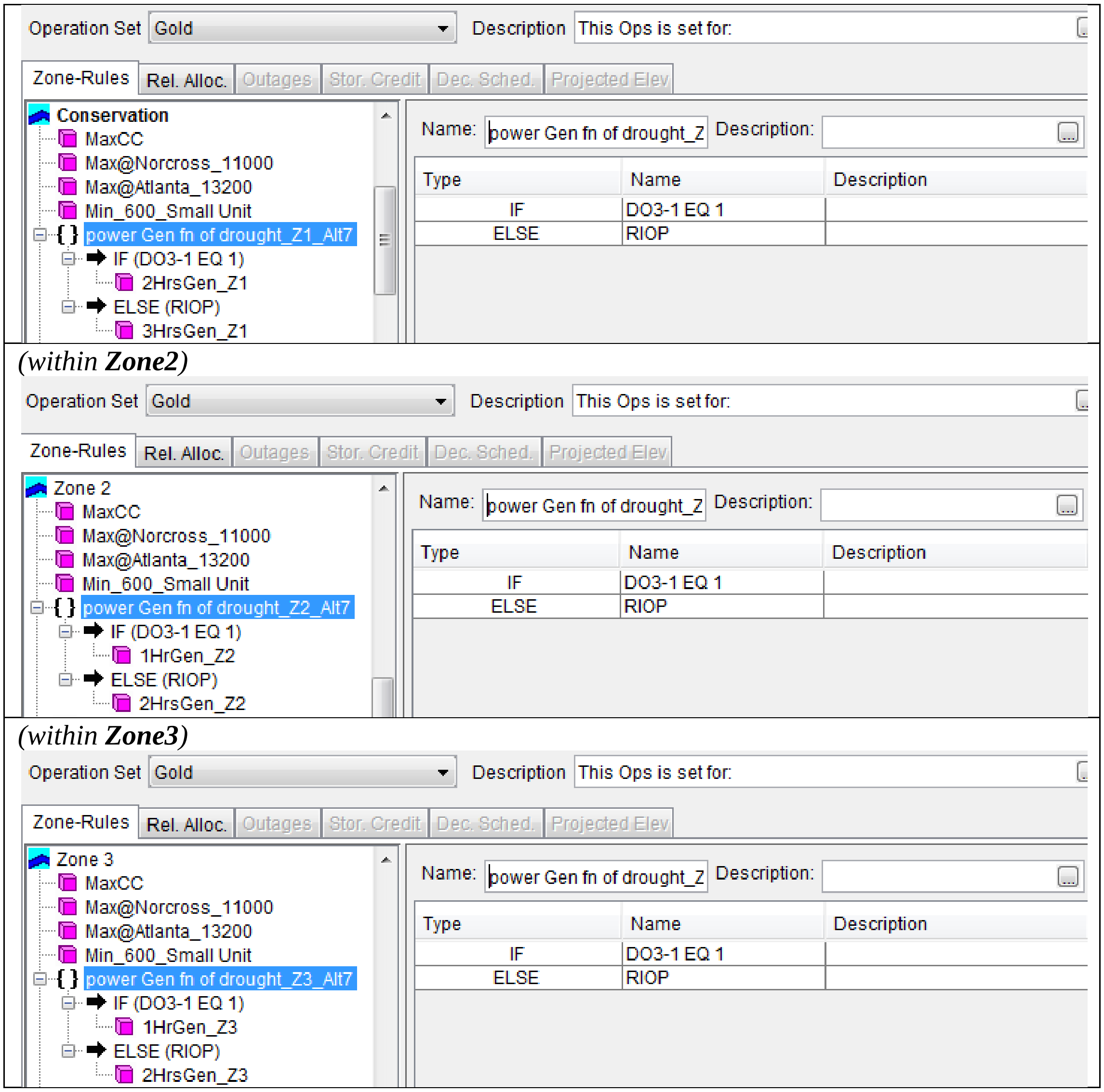


Figure K.87 Alternative 7 Operation Set Hydropower Rules

B. Jim Woodruff

The Gold operation set retains all the rules and settings from NO-Action, with rules added to accommodate measures relating to navigation, and Trigger Drought Operation at Zone 3.

1. Navigation (4-5) month_DO3-1

The "Navigation(4-5 month)_DO3-1" rule closely resembles the Navigation operation rule from the Silver operation set, except using a different definition of the drought condition (i.e., drought condition initiated if composite storage falls to level 3. This revised drought condition is represented by state variable Drought_Ops_3_1, as described in Append H. The description of Navigation(4-5) month_DO3-1 is shown in Figure K.88.

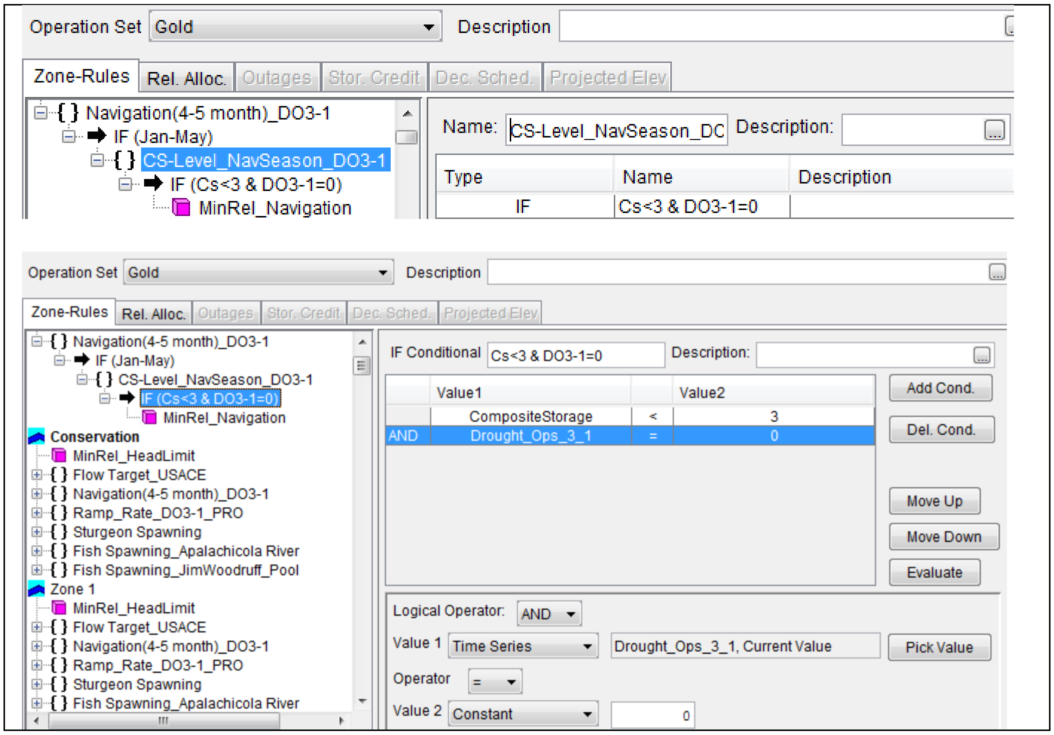


Figure K.88 Release Rules for Navigation (4-)month)_DO3-1Rule

2. Trigger Drought Operation at Zone 3

Drought operation definition is the same as NO-Action except the drought plan is "triggered" when composite storage falls below the bottom of Zone 2 into Zone 3 as shown in Figure K.89. Note that composite storages are defined based on Revised Action Zones.

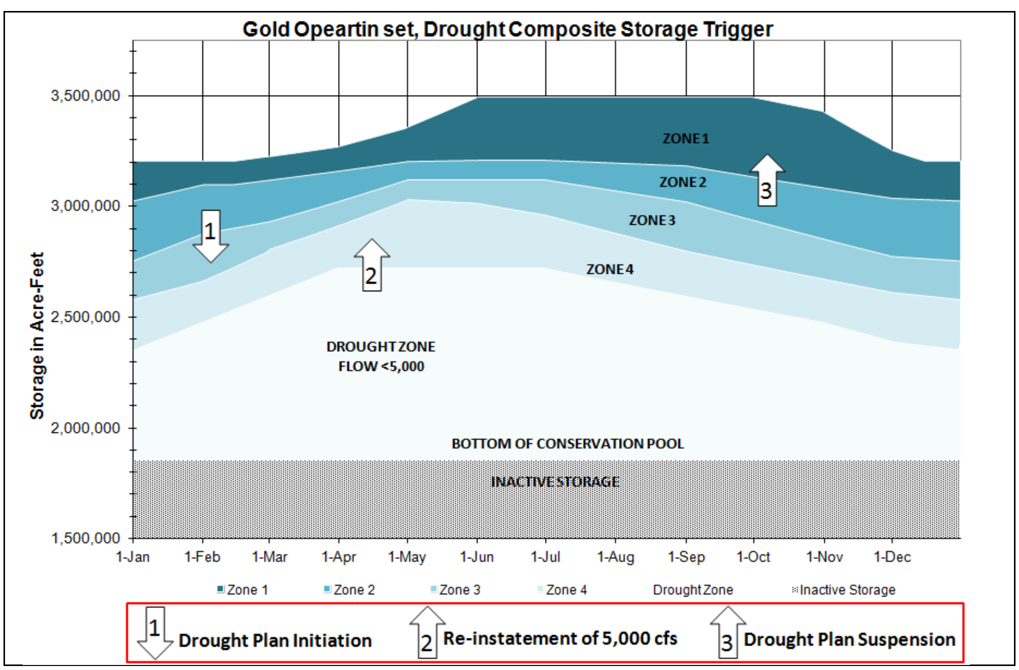


Figure K.89 Alternative 7-Drought Composite Storage Triggers

X. Water Supply Withdrawal Options

Figure K.90 shows eight different water supply withdrawal options proposed to apply in the model.

Based on alternatives defined in previous sections and proposed water supply options shown in Figure K.90 fifteen alternatives have been created in the model. The combination of alternatives and water supply options for these alternatives are shown in Table K.28.

Table K. 27 Combination of alternatives and water supply options

No.	Alter native Name	Alternative	Water Supply Option
1	NOActionAx	NO_Action	A
2	Alt1_OptBx	Alt1	B
3	Alt1_OptCx	Alt1	C
4	Alt2_OptBx	Alt2	B
5	Alt3_OptBx	Alt3	B
6	Alt4_OptBx	Alt4	B
7	Alt5_OptBx	Alt5	B
8	Alt6_OptBx	Alt6	B
9	Alt7_OptAx	Alt7	A
10	Alt7_OptBx	Alt7	B
11	Alt7_OptCx	Alt7	C
12	Alt7_OptDx	Alt7	D
13	Alt7_OptEx	Alt7	E
14	Alt7_OptFx	Alt7	F
15	Alt7_OptHx	Alt7	H

Alternative					Net Water Supply Consumption Upstream of Buford Dam (mgd)									Net Water Supply Consumption at Atlanta (Chattahoochee River Below Buford Dam)		
Description	Total Water Supply Withdrawal Upstream of Buford and Downstream at Atlanta	Lanier Withdrawals (Gross)			Total Withdrawals Upstream of Buford Dam				Total Returns Upstream of Buford Dam[1]				Upstream Net Withdrawals	River Withdrawals	River Returns	River Net Withdrawals
		Relocation	'56 Act*	WSA*	**Upper Chattahoochee Withdrawals	Glades Withdrawal	Lanier Withdrawals	Subtotal	**Upper Chattahoochee Returns	Glades Returns	Lanier Returns	Subtotal				
A - NEPA No Action	412.5 (135.5+277)	20	10	98	7.5	0	128	**135.5**	1	0	37 29 %	**38**	**97.5**	277	227 (82 %)	50
B – No WSA or '56	304.5 (27.5+277)	20	0	0	7.5	0	20	**27.5**	1	0	10 50%	**11**	**16.5**	277	227 (82 %)	50
C - Future Without W/Glades pumping	475.5 (67.5+408)	20	0	0	7.5	40	20	**67.5**	1	22 55%	10 50%	**33**	**34.5**	408	335 (82 %)	73
D - GA 2013	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	163 55%	**164**	**140.5**	408	384 (94 %)	24
E – GA 2013 w/Glades pumping	712.5 (304.5+408)	20	10	227	7.5	40	257	**304.5**	1	22 55%	141 55%	**164**	**140.5**	408	384 (94 %)	24
F - GA 2013 Current Returns	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	91 30.6%	**92**	**212.5**	408	335 (82 %)	73
G - GA 2013 Max Treatment Facility Capacity	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	128 43%	**129**	**175.5**	408	477 (117 %)	69***
H - 2066	680.5 (272.5+408)	*20*	*10*	*155*	*7.5*	*40*	*185*	***232.5***	*1*	*16 40.4%*	*75 40.4%*	**92**	***140.5***	*408*	*384* (94 %)	*24*

[1]For purposes of this table, "returns" are defined as treated wastewater discharges by the entities that withdraw water for municipal and industrial use upstream of Buford Dam or from the Chattahoochee River at Atlanta. Because these returns vary in relation to the amount of water supply withdrawals evaluated under the different alternatives, it is necessary to estimate and consider the varying amounts of returns along with withdrawals for each alternative.

*Volumes in the columns titled WSA and '56 Act reflect withdrawals that could be accommodated under the Water Supply Act or the 1956 Act . For the NEPA No Action (Water Supply Option A) numbers have been entered to reflect withdrawals that are currently occurring; however, no WSA or '56 Act agreements have been entered into.

**The Upper Chattahoochee withdrawal and returns above Buford are based on year 2007 actual water use.

***Refers to a net gain in river volume due to returns in excess of 100%

River returns were updated to 2012 as a result of new information provided by GA EPD.

Note that although the 257 option appears "intermediate" when compared to 297, alternatives D and E are identical in terms of total water supply use. That is not a problem, just an observation.

Option E: This water supply option developed to reflect 40 mgd being provided by Glades (i.e., Glades is a partial supplier of H2O)

We need to insert some return figures here, because otherwise it is not apparent why these alternatives wouldn't be reasonable. (I believe they would exceed available storage, but assuming returns could be increased enough they would not, correct?)

Future without w/Glades pumping: Assumes no further action under WSA/'56 Act, but releases will be made to accommodate downstream water supply withdrawals.

GA 2013 – Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will not undergo full impacts analysis because the volumes represented in this water supply option are 'bracketed' (i.e., are between) values in other water supply options that will undergo full analysis. It is reasonable to assume that impacts from GA 2013 - Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will be reflected in analysis conducted for other options.

No Action Lanier returns are drawn from year 2012. Gwinnett County's Wayne Hill treatment facility became action in 2010, resulting in increased return rates. Source of new volumes is GA EPD, provided in response to SAM request for the most current data.

No Action Lanier withdrawals are drawn from year 2007 because 2007 was the year of greatest net water use in the ACF basin.

Figure K.90 Water Supply Withdrawal Options

As shown in Figure K.90, in water supply options C, E, and H 40 mgd is withdrawn from Glades reservoir. In water supply options C and E 55% of that is returned to Buford and in water supply option H 40.4% is returned to Buford.

As mentioned in section III.A. in the NO_Action operation set at Glades there is a "Zero Pump From Glades" rule that limits the withdrawal from Glades to zero. For water supply options C, E, and H another operation set named "Water Supply" is defined as shown in Figure K.91. This operation set includes a "Pump From Glades" rule as shown in Figure K.92.This rule represents the annual average of 40 mgd withdrawal from glades.

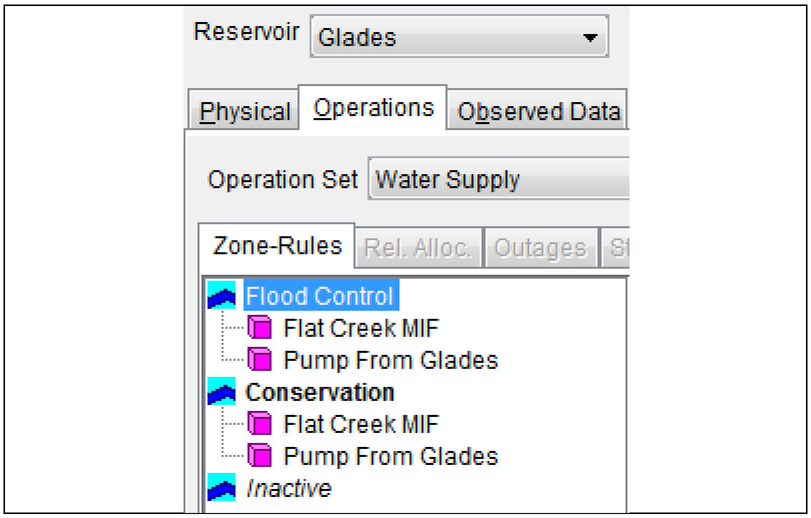


Figure K.91 Rule Set for Glades Water Supply Operation Set

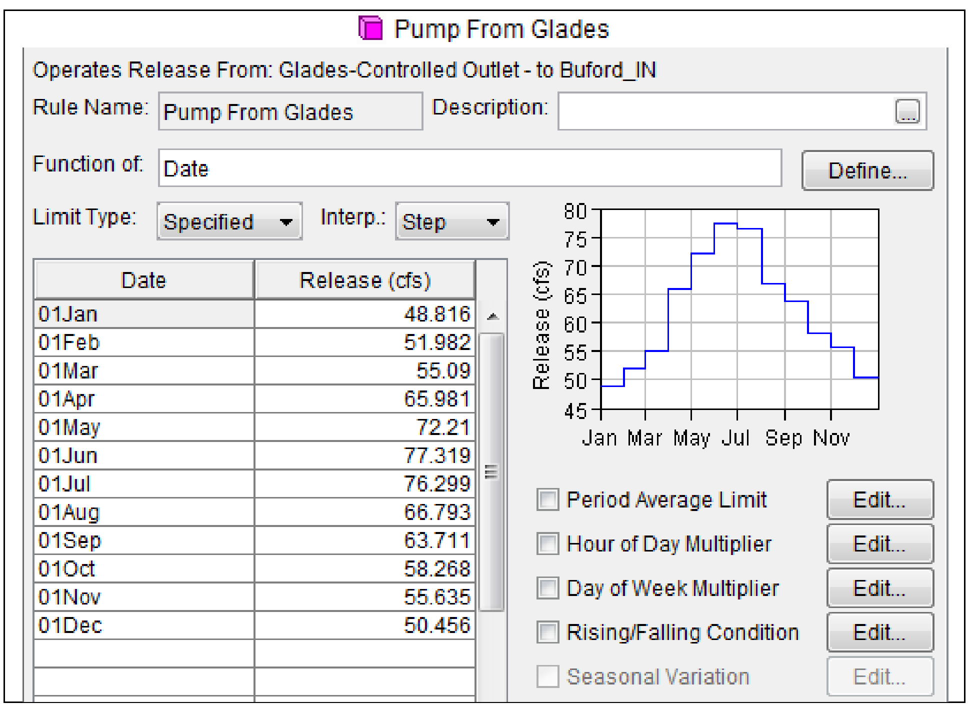


Figure K.92 Glades Reservoir –*Pump From Glades* rule

The return rate for water supply option C, and E is 55%. This value is defined in the physical tab under "Losses" section of the "Routing" branch of the Diverted Outlet as shown in Figure K.93.

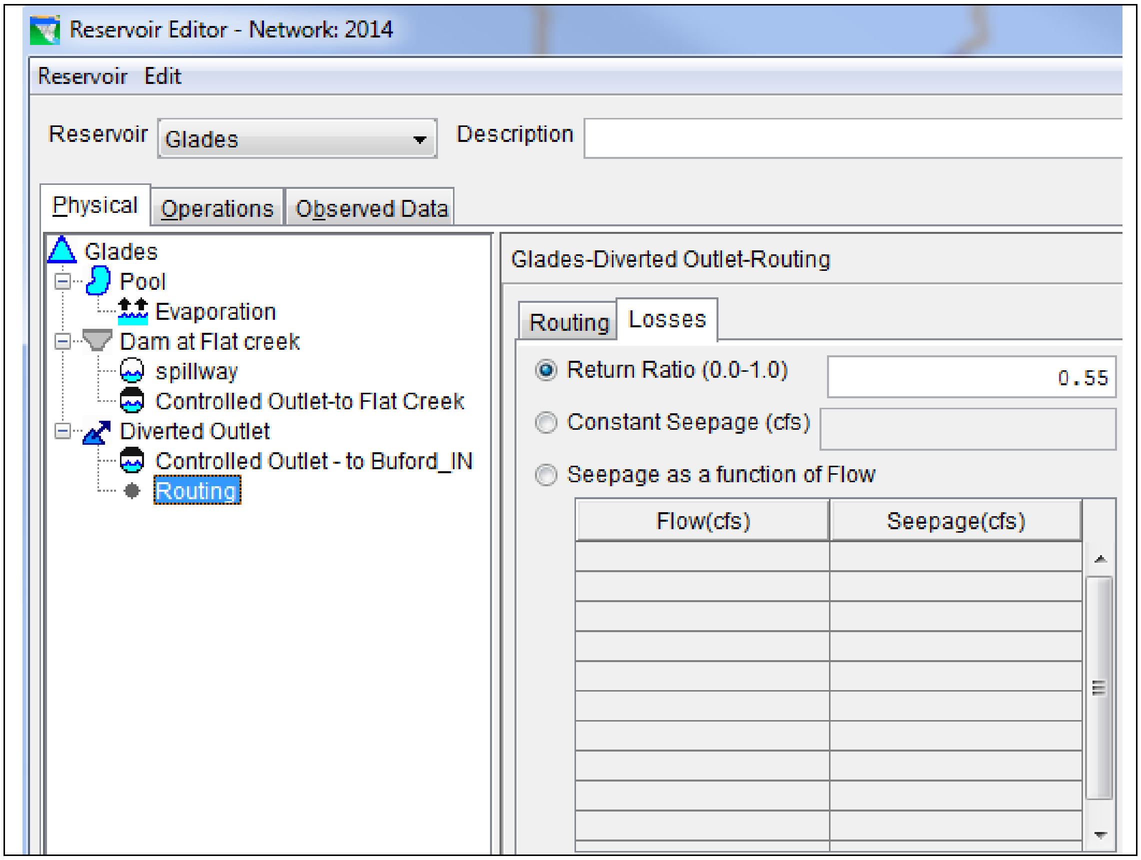


Figure K.93 Return rate from Glades to Buford-Water supply options C and E

This value is 40.4% for water supply option H. Since this is a change in the network, water supply option H is defined based on new Network named "2014_OptH".The return rate ratio for water supply option H is shown in Figure K.94.

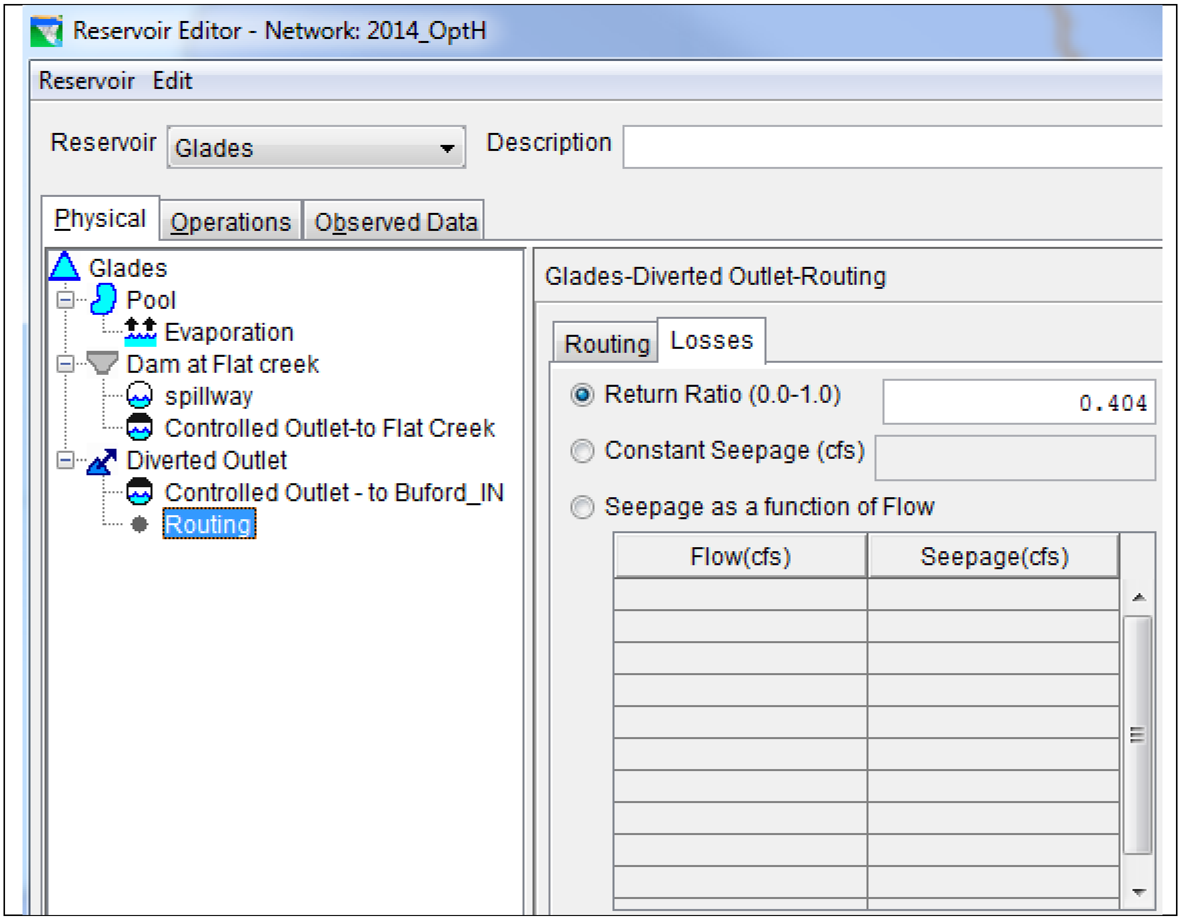


Figure K.94 Return rate from Glades to Buford-Water supply option H

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment

Addendum - Response to Comments

12 June 2016

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Table of Contents

List of Tables

List of Figures

I. Introduction

This document is an addendum to the June 2014 report, "ACF HEC-ResSim Modeling of Reservoir Operations in Support of the Water Control Manual Update and Water Supply Storage Assessment". This addendum was written to document the model changes that were made in response to comments received as part of the Water Control Manual Update Environmental Impact Statement (EIS) review and submittal process required under the National Environmental Policy Act (NEPA).

The June 2014 report describes reservoir system modeling activities performed in support of the Mobile District Water Control Manual Update for the Apalachicola-Chattahoochee-Flint (ACF) River Basin (Figure 1). The reservoir system model performs simulations of project operations for a baseline condition. In concept, the Water Control Manual Update only required comparison of alternatives for relative differences in the results, but in practice, the plan formulation process depended on results being as realistic as possible, to provide feedback regarding serious and complex questions posed along the way. Additionally, the Mobile District intends to apply models developed under this study for other purposes, including cooperative follow-up activities with stakeholders, and operational use for real-time decision support. Consequently, the baseline reservoir system model eventually grew to include the detailed physical characteristics (as available) and almost all the operational rules used at each project in the system.

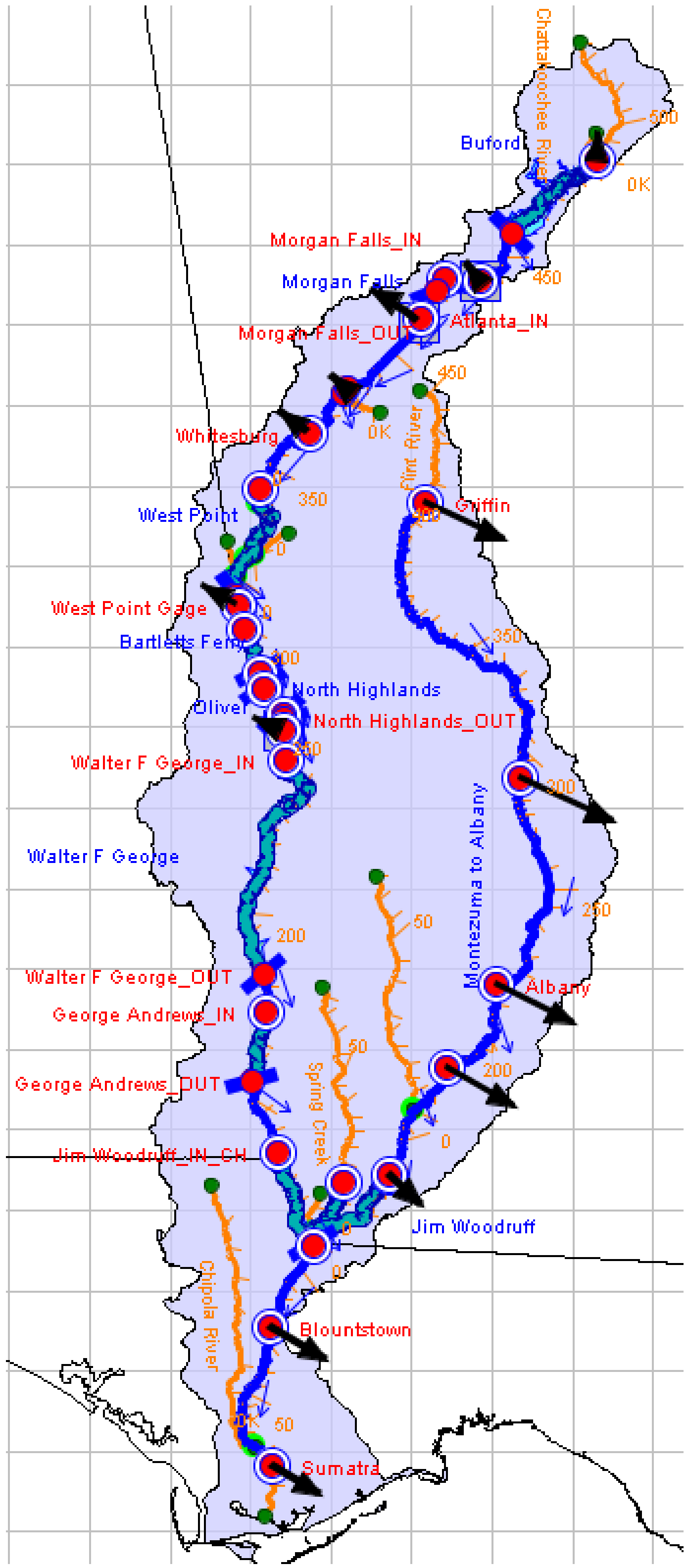


Figure 1. HEC-ResSim 2016 Network Schematic

The primary output of the reservoir system modeling activities consisted of 73 years (1939-2011) of continuously simulated daily lake levels and river flows throughout the ACF basin. Project Delivery Team (PDT) members evaluated the impact of these results in terms of economic, environmental, and operational improvements or disadvantages. The comments and recommendations received from the EIS and model reviewers caused the PDT to make some changes to the model and to add a new operational alternative to reflect a composite of the ACF Stakeholders operational suggestions.

A. Overview of Model Changes

The most significant changes to the model involved the removal of the Glades and Bear Creek reservoirs. A description of the changes required to accomplish this are included in ***section II*** of this report.

A number of other modifications made to the model are described in ***section III*** of this report. These modifications include: an updated elevation-storage-area curve at Buford, five new water supply scenarios, and six new alternatives to support biological assessment.

A new operational alternative was added to the model in response to the review comments and recommendations from the ACFS stakeholders group. The "ACFS" alternative is described in ***section IV*** of this report.

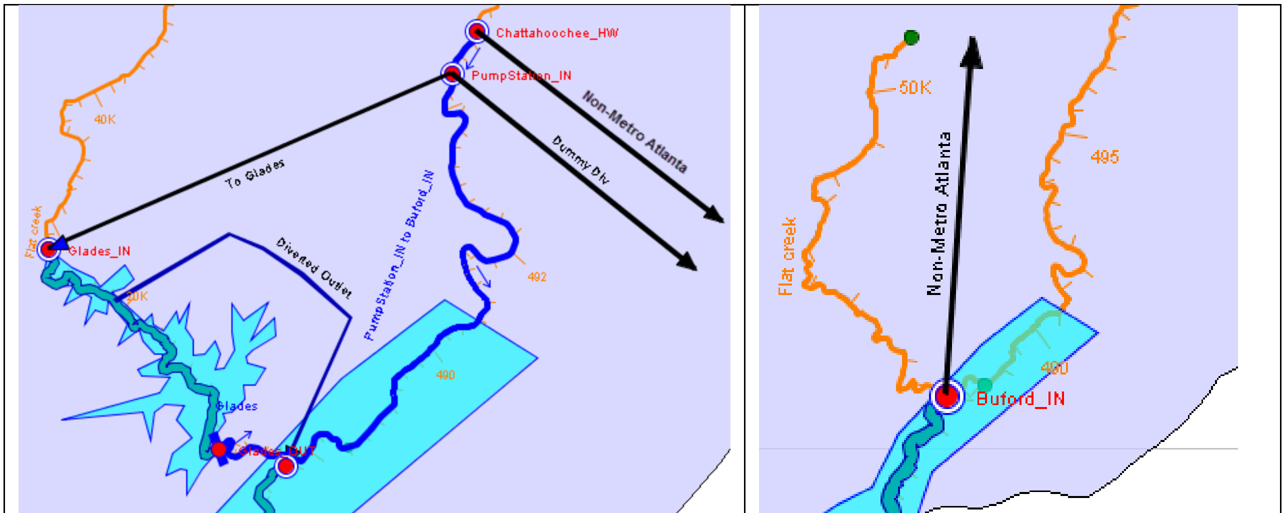
These changes necessitated the development of a new network, and new alternatives. These new model components are described throughout this report.

B. HEC-ResSim Improvements

The updated modeling was performed in a new version of HEC-ResSim. Model results delivered in 2014 were computed using a developmental version of HEC-ResSim version 3.2 (build 3.2.1.19). The June 2016 model results were computed using a release candidate of HEC-ResSim version 3.3 (build 3.3.1.42). Although this newer version of ResSim has not yet been officially released, it offers important advantages over ResSim 3.2, including new features, enhancements, bug fixes, and improved algorithms.

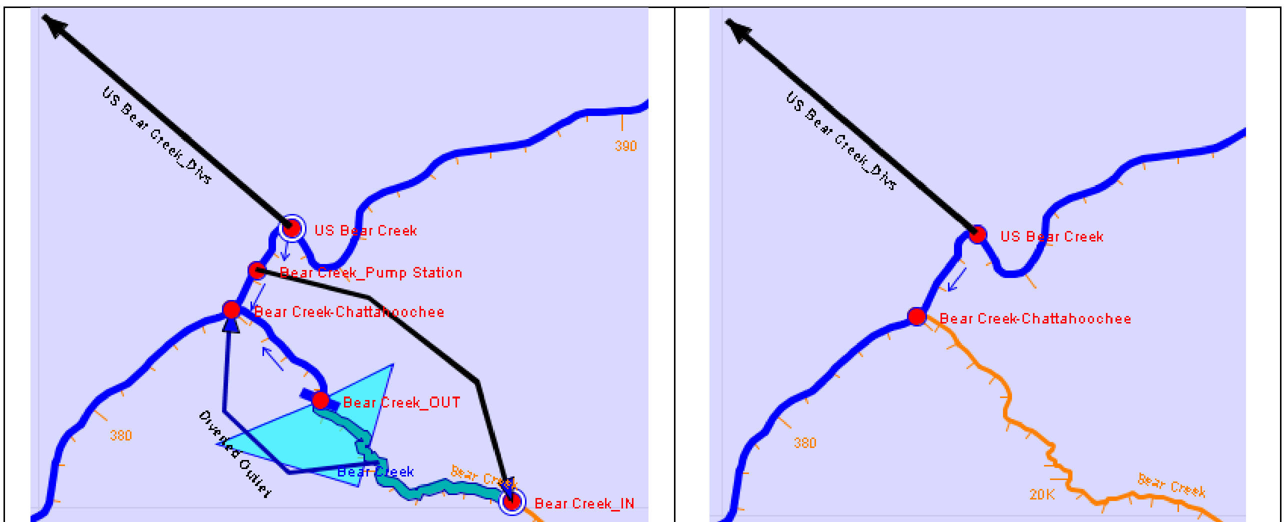
II. Removal of Glades and Bear Creek Reservoirs

Although Glades and Bear Creek reservoirs were only proposed additions to the basin, they were included in the original, 2014 model because construction was reasonable and foreseeable. At the time the USACE Savannah District was considering a permit application for the construction of the two projects for water supply. However, the permit application to build both Glades and Bear Creek reservoirs has been withdrawn by applicants. For this reason, Glades and Bear Creek reservoirs were removed from the model in the 2016 network. Figure 2 shows the 2014 and 2016 networks in the region of Glades reservoir. Figure 3 shows the 2014 and 2016 network in the region of Bear Creek reservoir.



With Glades Reservoir | Without Glades reservoir

Figure 2. 2014 Network with Glades and 2016 Network without Glades



With Bear Creek Reservoir | Without Bear Creek Reservoir

Figure 3. 2014 Network with Bear Creek and 2016 Network without Bear Creek

With the removal of Glades and Bear Creek reservoirs, the discretization of the inflows and diversions above Buford and West Point were simplified. Table 1 shows the inflow and diversion time series used above Buford and West Point in the 2014 network and Table 2 shows the inflow and diversion time series used in the 2016 network.

Table 1. Local flows in the region of Glades and Bear Creek reservoirs in 2014 network

Chatt_HW_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATAHOOCHEE RIVER	PUMP STATION	FLOW	1DAY	EXTENDED RECORD X 1.187
PumpStation_IN_LOC	Known Flow	shared/TOTALDEMANDS_ver11.dss	ACF BASIN	ZERO	FLOW-DIV	1DAY	ZERO DEMAND
Glades_IN_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	FLAT CK	GLADES_IN	FLOW	1DAY	EXTENDED RECORD X 0.374
Buford_IN_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATAHOOCHEE RIVER	BUFORD_DIRECT	FLOW	1DAY	UNIMPAIRED MINUS PS + FLA
Metro Atlanta	Known Flow	shared/ACF_WaterSupplyOptions_01J	ACF BASIN	BUFORD	FLOW-DIV	1DAY	OPTIONB(20 MGD 50%RT)
10 MGD_Rel Contract	Known Flow	shared/TOTALDEMANDS_ver11.dss	ACF BASIN	ZERO	FLOW-DIV	1DAY	ZERO DEMAND
US Bear Creek_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATTAHOOCHEE	US BEAR_LOC	FLOW_INC	1DAY	UNIMP_CMA7_MINUS_BEAR
Bear Creek_IN_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	BEAR CREEK	BEAR CK RES	INFLOW	1DAY	ESTIMATED
Whitesburg_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATTAHOOCHEE	WHITESBURG_LOC	FLOW_INC	1DAY	UNIMP_CMA7_MINUS_BEAR

Table 2. Local flows in the region of Glades and Bear Creek reservoirs in 2016 network

Buford_IN_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATTAHOOCHEE	BUFORD	FLOW_INC	1DAY	UNIMP_CMA7
Metro Atlanta	Known Flow	shared/ACF_WaterSupplyOptions_10M	ACF BASIN	BUFORD	FLOW-DIV	1DAY	OPTIONB(20 MGD 50%RT)
10 MGD_Rel Contract	Known Flow	shared/TOTALDEMANDS_ver11.dss	ACF BASIN	ZERO	FLOW-DIV	1DAY	ZERO DEMAND
Whitesburg_LOC	Known Flow	shared/ACFCUM_11_30May2014.dss	CHATTAHOOCHEE	WHITESBURG	FLOW_INC	1DAY	UNIMP_CMA7

III. Other Model Updates

In addition to the removal of Glades and Bear Creek reservoirs, two other modifications were made to the ACF system model. The first modification is an update to the elevation-storage-area relationship for Buford reservoir which reflects the most recent survey of the reservoir pool. The other modification is the addition of five new water supply options (scenarios) and their associated alternatives.

A. Updated Pool Data at Buford

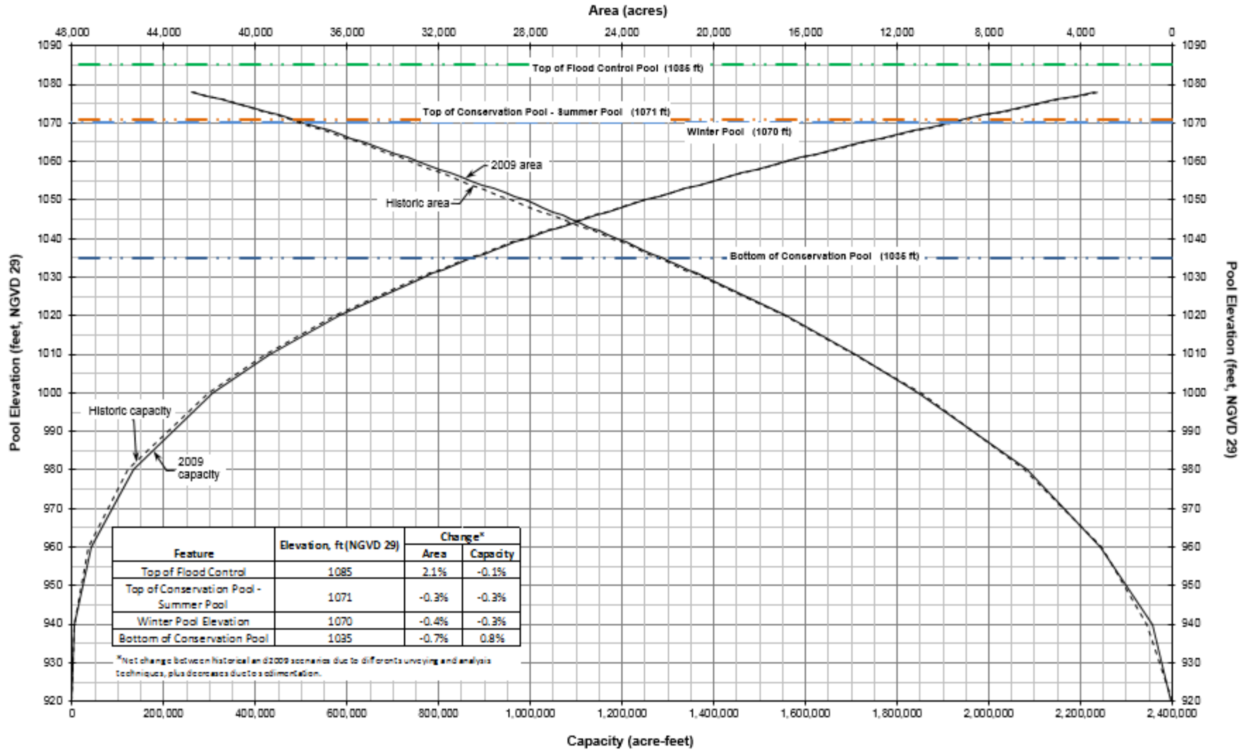
The historic and recommend storage-area-capacity tables for Buford/Lake Lanier are shown in Figure 4 and illustrated in Figure 5.

Elevation (ft)	Storage (ac-ft)	Area (acre)
920	0	0
940	5000	1090
960	37000	3100
980	121000	6450
1000	296500	10984
1010	420200	13819
1020	574000	16912
1030	760100	20508
1031	781000	20894
1032	802000	21281
1033	823600	21668
1034	845600	22055
1035	867600	22442
1036	890300	22829
1037	913300	23217
1038	936500	23690
1039	960500	24008
1040	984500	24416
1041	1009300	24833
1042	1034300	25257
1043	1059900	25701
1044	1085900	26159
1045	1112200	26619
1046	1139200	27079
1047	1166300	27535

Elevation (ft)	Storage (ac-ft)	Area (acre)
920	95	42
940	6256	831
960	43107	3134
980	135503	6316
1000	305933	11052
1010	429804	13805
1020	582456	16842
1030	767841	20352
1031	788353	20728
1032	809245	21119
1033	830529	21509
1034	852203	21897
1035	874268	22293
1036	896728	22681
1037	919575	23068
1038	942809	23449
1039	966424	23833
1040	990425	24223
1041	1014817	24617
1042	1039602	25006
1043	1064778	25399
1044	1090348	25795
1045	1116316	26200
1046	1142692	26613
1047	1169481	27019

1048	1194300	27983	1048	1196678	27433
1049	1222300	28432	1049	1224294	27850
1050	1250900	28861	1050	1252328	28262
1051	1279900	29291	1051	1280779	28698
1052	1309500	29721	1052	1309672	29149
1053	1339500	30153	1053	1339020	29616
1054	1369800	30587	1054	1368838	30094
1055	1400800	31023	1055	1399137	30569
1056	1431800	31461	1056	1429913	31043
1057	1463800	31901	1057	1461162	31509
1058	1495800	32343	1058	1492878	31969
1059	1528200	32789	1059	1525056	32436
1060	1561200	33238	1060	1557706	32914
1061	1594700	33690	1061	1590836	33397
1062	1628700	34147	1062	1624451	33883
1063	1663000	34610	1063	1658555	34370
1064	1698000	35079	1064	1693147	34853
1065	1733100	35555	1065	1728222	35332
1066	1769100	36036	1066	1763777	35806
1067	1805200	36522	1067	1799806	36276
1068	1842200	37015	1068	1836307	36753
1069	1879200	37515	1069	1873292	37257
1070	1917000	38024	1070	1910800	37871
1071	1955200	38542	1071	1948913	38425
1072	1994200	39078	1072	1987580	38974
1073	2033600	39638	1073	2026797	39533
1074	2073600	40226	1074	2066587	40148
1075	2114000	40833	1075	2107015	40896
1076	2155000	41458	1076	2148182	41514
1077	2196900	42086	1077	2189968	42138
1078	2239300	42716	1078	2232382	42785
1079	2282300	43348	1079	2275460	43536
1080	2326000	43982	1080	2319345	44794
1081	2370300	44618	1081	2364423	45440
1082	2415300	45256	1082	2410136	46057
1083	2460800	45896	1083	2456466	46678
1084	2507000	46538	1084	2503423	47352
1085	2554000	47182	1085	2551064	48176
1090	2800000	50250	1090	2798297	50783
1095	3070000	53300	1095	3058485	53459
1100	3330000	56500	1100	3332548	57601
1110	3850000	62900	1110	3908559	57602
The Historic Table			The Recommended Table		

Figure 4. The historic and recommended elevation-storage-area values at Buford



Feature	Elevation, ft (NGVD 29)	Change*	
		Area	Capacity
Top of Flood Control	1085	2.1%	-0.1%
Top of Conservation Pool - Summer Pool	1071	-0.3%	-0.3%
Winter Pool Elevation	1070	-0.4%	-0.3%
Bottom of Conservation Pool	1035	-0.7%	0.8%

*Net change between historical and 2009 scenarios due to different surveying and analysis techniques, plus decreases due to sedimentation.

Figure 5. The historic and recommended elevation-storage-area curve at Buford

B. New Water Supply Options

The PDT defined five new water supply options, I, J, K, L, and M, which are detailed in Figure 6 along with three of the original water supply options. . The PDT selected 10 alternatives to consider that combine these 8 water supply options with the Alternative 1 and 7 operations (described in section IV.C of the June 2014 report). The ten alternatives and their associated operation sets and water supply options are listed in Table 3

Water Supply Option	Lake Lanier relocation (mgd)	Lake Lanier reallocation (mgd)	Lake Lanier total withdrawals (mgd)	Lake Lanier returns (mgd/% returned)	Glades Reservoir withdrawals (mgd)	Glades Reservoir returns (mgd/% returned)	Net withdrawals from Lake Lanier (mgd)	River withdrawals (mgd)	River returns (mgd/% returned
A - No Action	20	108	128	37/29%	0	0	91	277	227/82%
B – Relocation only	20	0	20	10/50%	0	0	10	277	227/82%
H - Projected return volume for 2035 w/Glades pumping	20	165	185	74.7/40.4%	40	16/40.4%	110.3	408	384/94%
I – Option H for Lanier w/o Glades, GA 2015 Request Downstream	20	205	225	91/40.4%	0	0	134	379	361/95%
J – Future without project condition	20	0	20	10/50%	0	0	10	379	361/95%
K – GA 2015 Request	20	222	242	104/43.2%	0	0	137.4	379	361/95%
L – Current Lake withdrawals (with GA 2015 downstream withdrawals)	20	108	128	37/29%	0	0	91	379	361/95%
M – Increased Lanier (with GA 2015 downstream withdrawals)	20	165	185	74.7/40.4%	0	0	110.3	379	361/95%

Figure 6. Water Supply Withdrawal Options

Table 3. Combination of alternatives and water supply options

No.	Alternative Name	Alternative	Water Supply Option
1	Alt7_OptHx	Alt7	H
2	Alt7_OptAN	Alt7	A
3	Alt7_OptBN	Alt7	B
4	Alt7_OptIN	Alt7	I
5	Alt7_OptJN	Alt7	J
6	Alt7_OptKN	Alt7	K
7	Alt7_OptLN	Alt7	L
8	Alt7_OptMN	Alt7	M
9	Alt1_OptAN	Alt1	A
10	Alt1_OptLN	Alt1	L

C. Biological Assessment Alternatives

To support the Biological Assessment of the ACF Basin Reservoir Operation, six more ResSim alternatives were created. These alternatives also use Alt1 and Alt7 operation sets but are combined with the historic water use and water supply options I, K, L, and M as the water diversion. Table 4 shows the selected combinations of operation sets, water supply options, and water used that make up the six alternatives used for the Biological Assessment.

Table 4. Biological assessment Alternatives

WM Alternative	Metro ATL Water Supply Scenario	Buford F-Part	Atlanta F-Part	Whitesburg F-Part	Water Supply Rest of Basin	F-Part
Alt1	O (Observed)	TOTAL WATER USE	TOTAL WATER USE PLUS ATL	TOTAL WATER USE MINUS ATL	Observed	TOTAL WATER USE
Alt7	O (Observed)	TOTAL WATER USE	TOTAL WATER USE PLUS ATL	TOTAL WATER USE MINUS ATL	Observed	TOTAL WATER USE
Alt7	I	OptionI(225 MGD 40.4%RT)	OptionI(379 MGD 95%RT)	OptionI(379 MGD 95%RT)+Non-Metro_2007	Observed	TOTAL WATER USE
Alt7	K	OptionK(242 MGD 43%RT)	OptionK(379 MGD 95%RT)	OptionK(379 MGD 95%RT)+Non-Metro_2007	Observed	TOTAL WATER USE
Alt7	L	OptionL(128 MGD 29%RT)	OptionL(379 MGD 95%RT)	OptionL(379 MGD 95%RT)+Non-Metro_2007	Observed	TOTAL WATER USE
Alt7	M	OptionM(185 MGD 40.4%RT)	OptionM(379 MGD 95%RT)	OptionM(379 MGD 95%RT)+Non-Metro_2007	Observed	TOTAL WATER USE

IV. ACFS Alternative

ACF Stakeholders, Inc. is a non-profit corporation with a Governing board of 56 stakeholder members representing interests from all areas of the Basin extending through Alabama, Florida and Georgia. The ACF Stakeholders (ACFS) mission is to change the operation and management of the ACF Basin to achieve equitable and viable solutions among stakeholders that balance economic, ecological, and social values and ensure that the entire ACF Basin is a sustainable resource for current and future generations.

As one of the ACF EIS reviewers, the ACFS group submitted a document to the PDT that contained their review comments and suggestions for improved operation of the ACF basin. In response, the PDT added a new operational alternative to the model to reflect their understanding of the ACFS's suggestions. This section describes the new or modified measures that are included in the ACFS alternative.

A. West Point Guide Curve

To enhance winter recreational opportunities, the winter pool elevation target for West Point Lake was changed from 628 ft to 632.5 ft. Figure 7 shows a plot of West Point's original "No Action" guide curve in blue with the suggested ACFS guide curve in red.

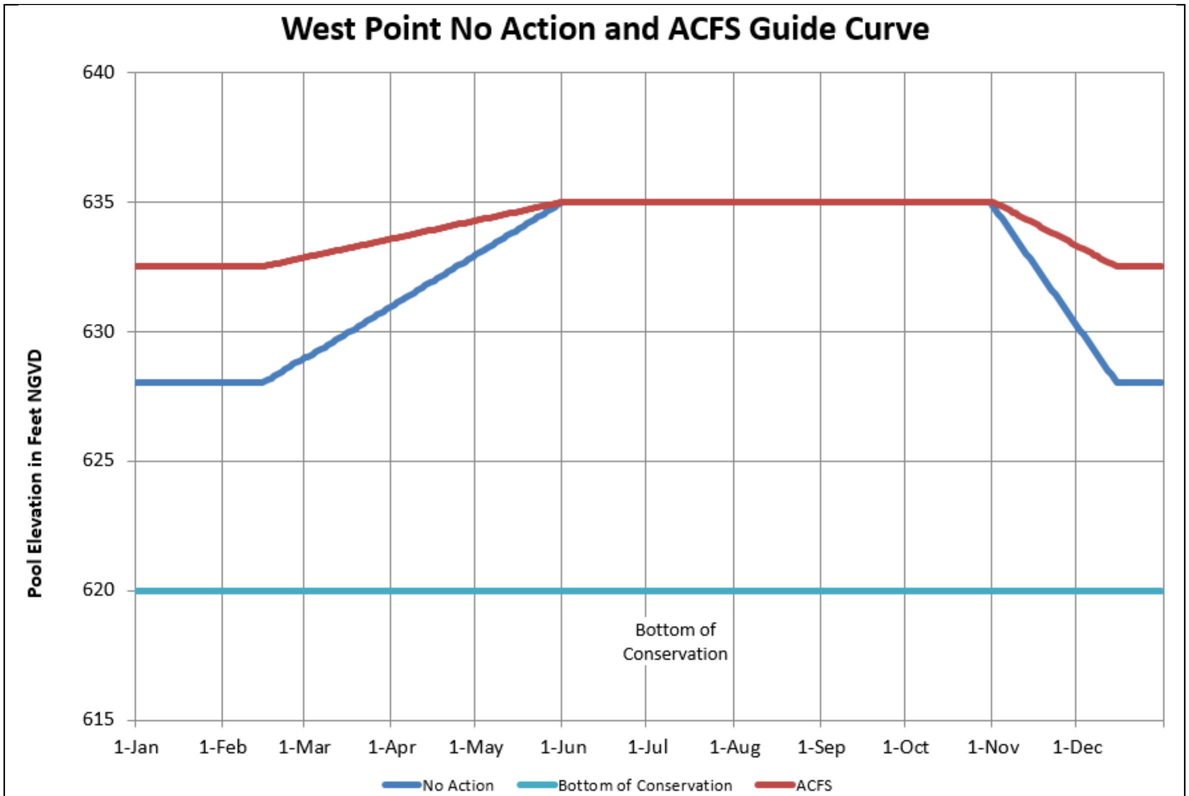


Figure 7. West Point No Action and ACFS guide curve

B. New Action Zones for each system project

New action zones were suggested to coincide with the USACE reservoir recreational impact zones. Combined with the new actions zones is a new balancing scheme for the storage in the system reservoirs - only release water from an upstream reservoir when the downstream reservoir is in a lower zone. Figure 8, Figure 9, and Figure 10 show the original revised action zones (solid lines) and recreational impact levels (dotted lines) at Buford, West Point, and Walter F George respectively.

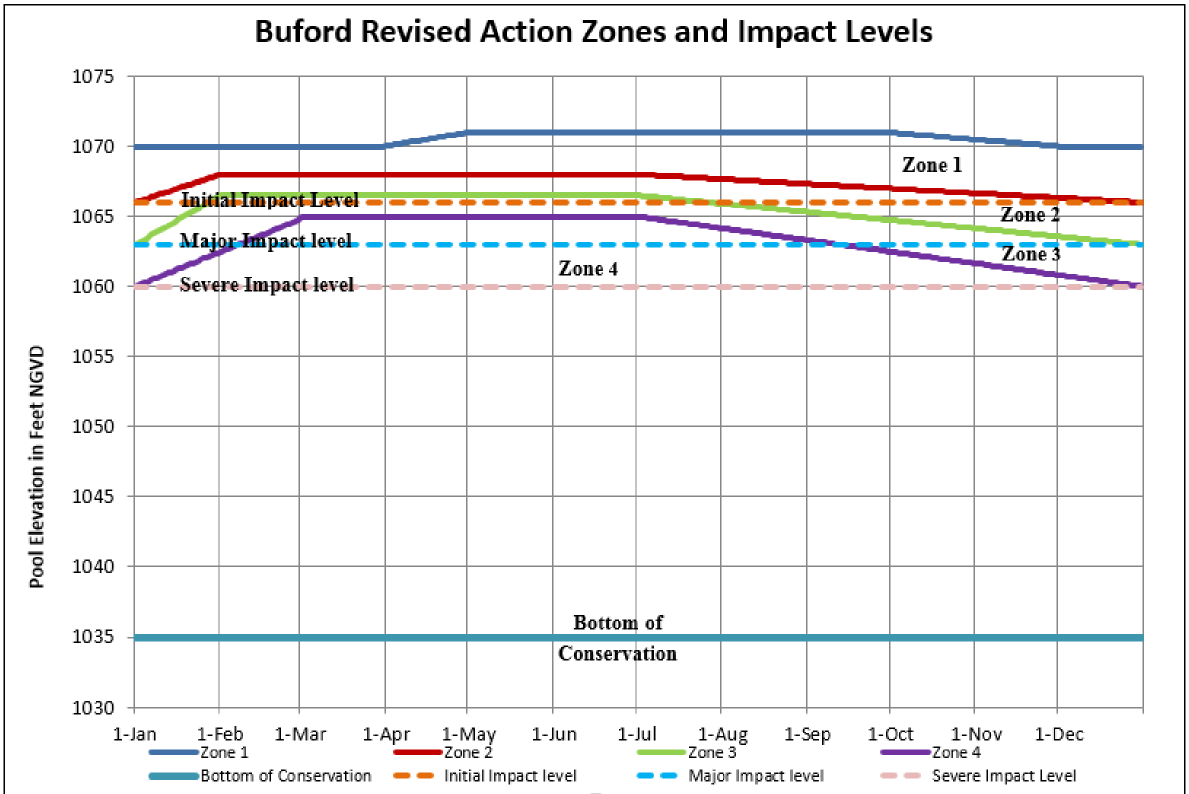


Figure 8. Buford Revised Action Zones and Impact levels

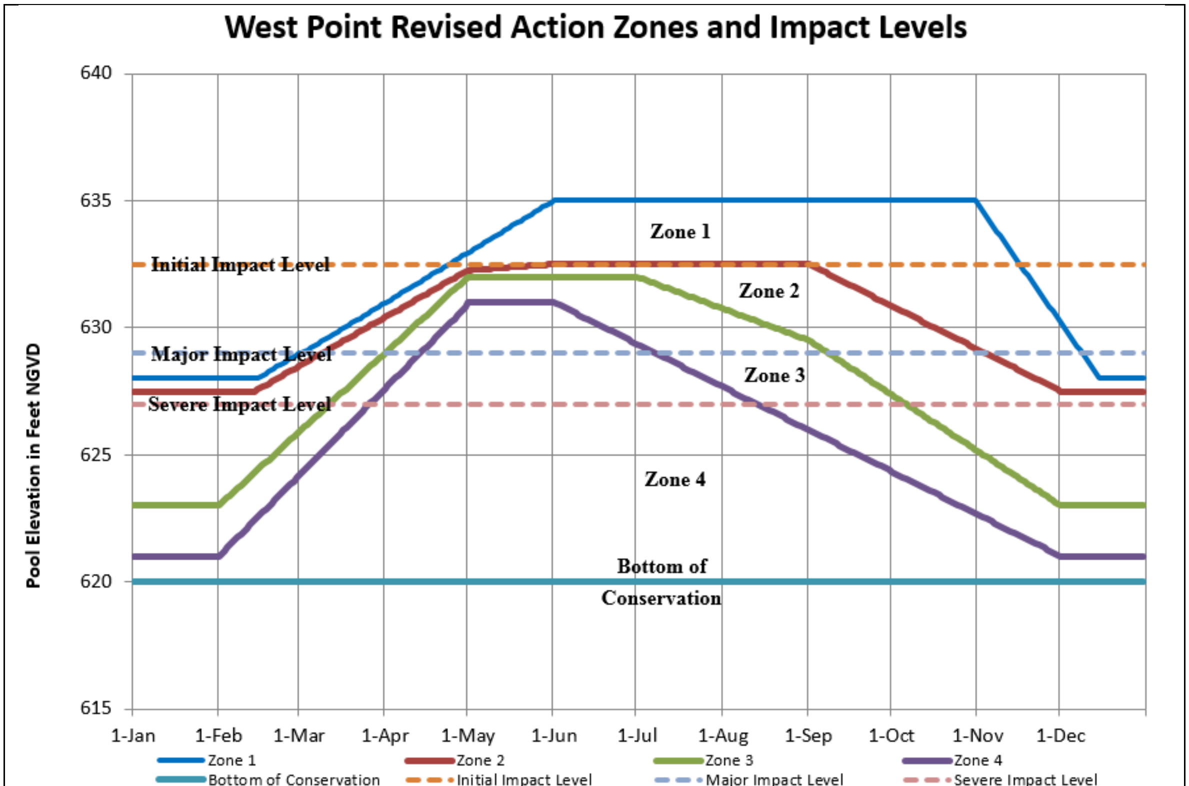


Figure 9. West point Revised Action Zones and Impact levels

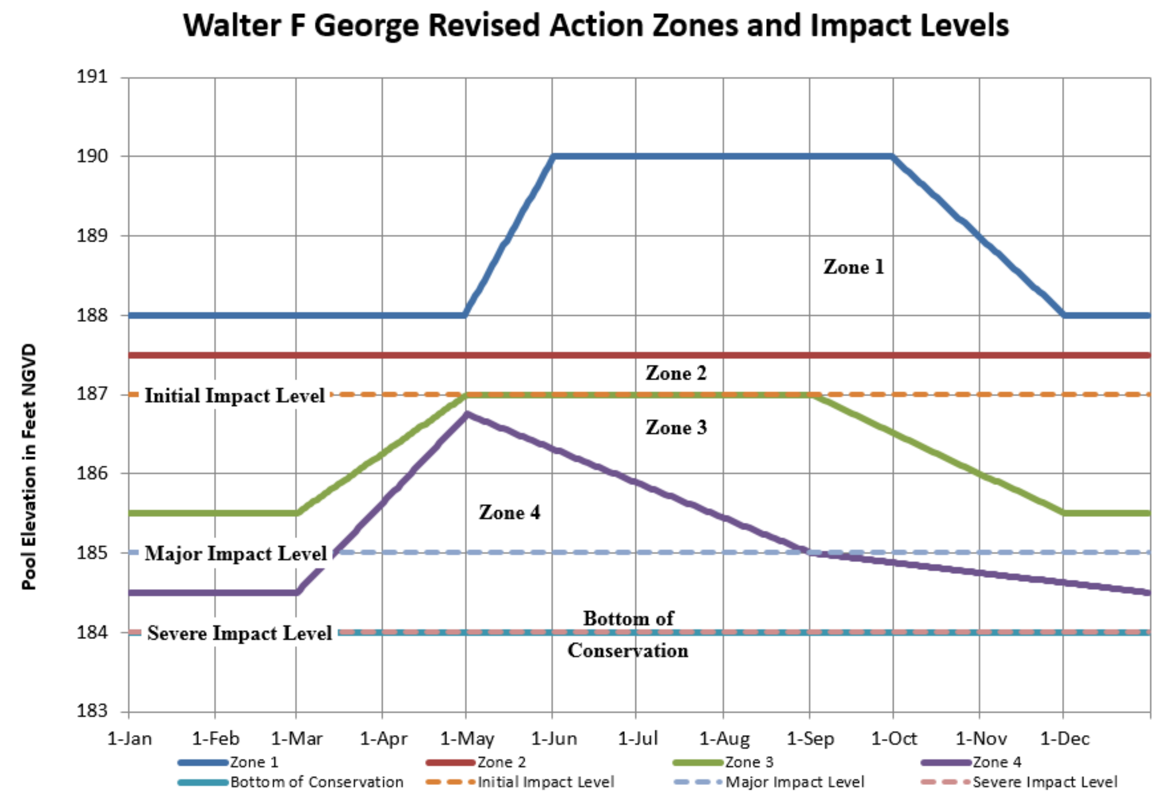


Figure 10. Walter F George Revised Action Zones and Impact levels

For the ACFS alternative, at Buford and West Point, the top of Zone 2 is set to the Initial Impact Level, the top of Zone 3 is set to the Major Impact Level, and the top of Zone 4 is set to the Severe Impact Level as shown in Figure 11 and Figure 12

At Walter F George, the assignment of the action zones to the impact levels was not straightforward since the Severe Impact Level coincides with the bottom of Conservation. In order to retain action zone 4 while still adhering as closely as possible to the ACFS's suggestion, the PDT defined the ACFS actions zones as follows: the top of Zone 2 is set to the Initial Impact Level (187 ft), the top of Zone 3 is set to 186 ft and the top of zone 4 is set to the Major Impact Level (185 ft) as shown in Figure 13.

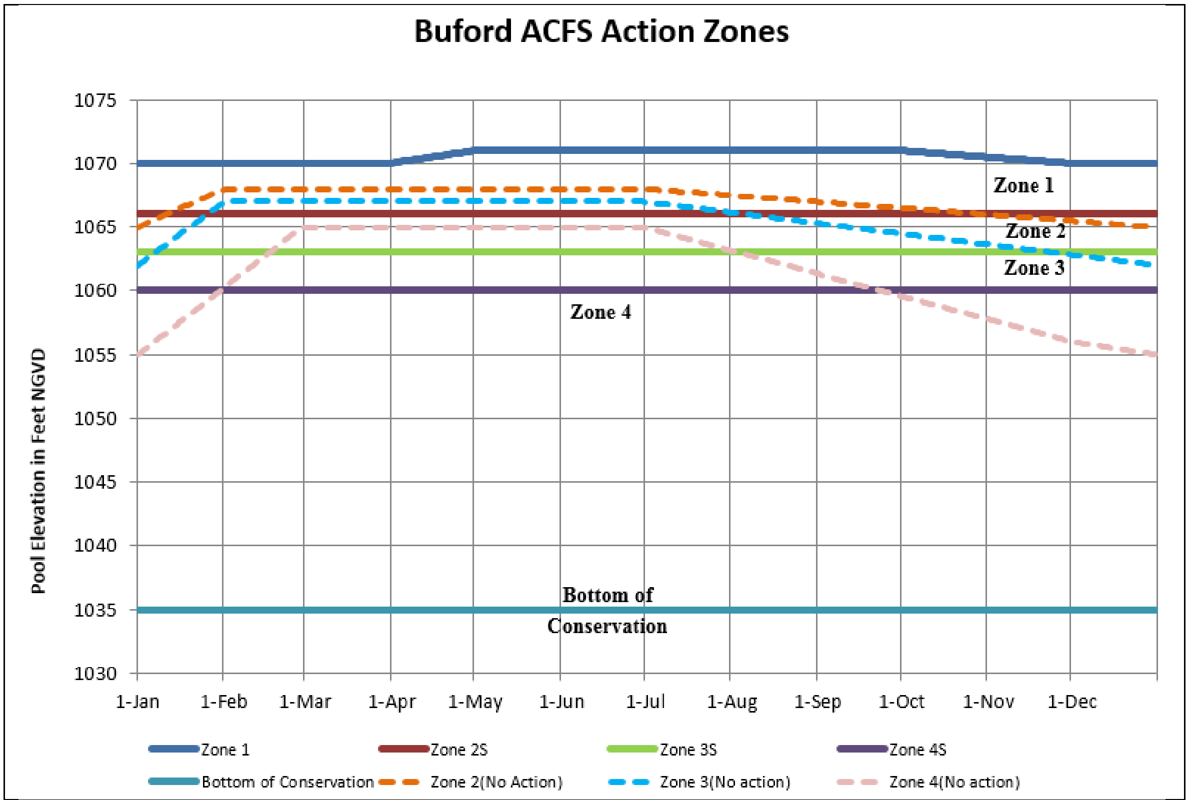


Figure 11. Buford ACFS Action Zones

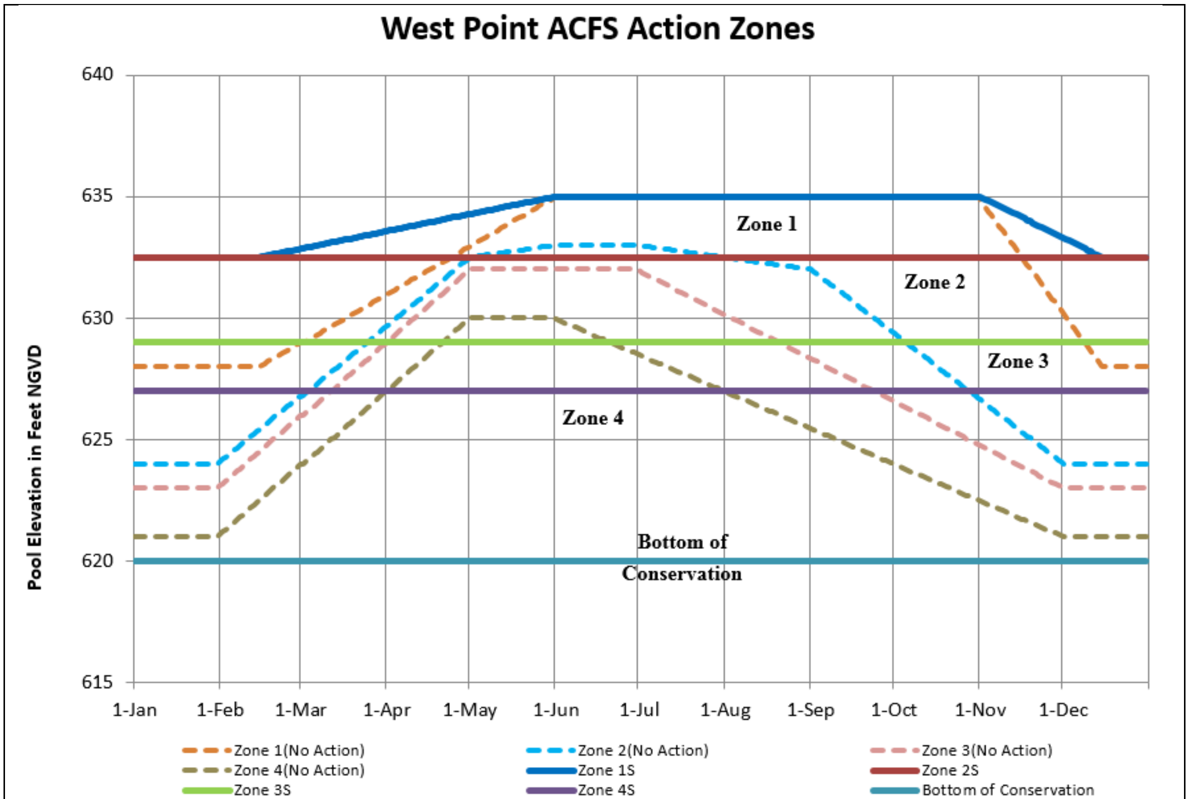


Figure 12. West point ACFS Action Zones

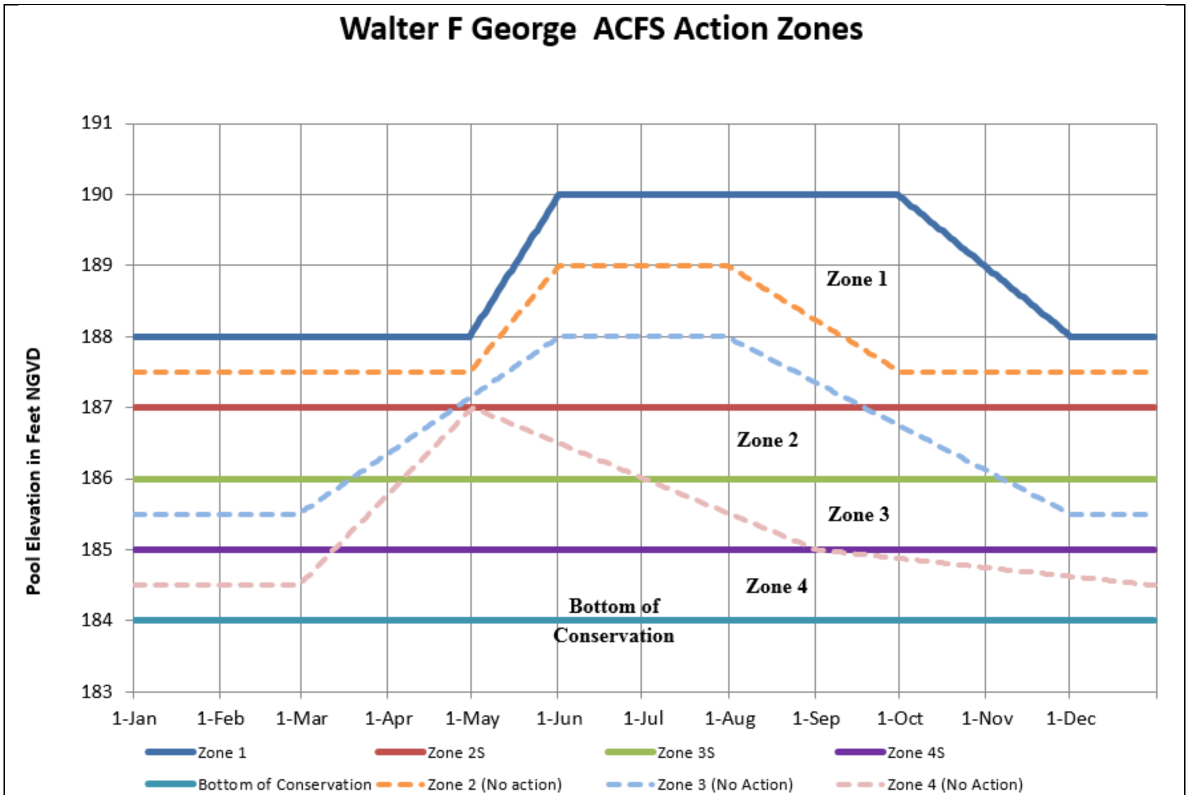


Figure 13. Walter F George ACFS Action Zones

C. Drought Operations

The drought operation use for ACFS alternative is the same as was used in the NO Action alternative described in *section III.A.2.c.c* of the June 2014 report except the drought plan is "triggered" when composite storage falls below the bottom of Zone 2 into Zone 3 as shown in Figure 14. Note that composite storages are defined based on the ACFS Action Zones. To implement the drought operation, the ACFS alternative uses the *Drought_Ops_3_1_ACFS* and *CompositeStorage_ACFS* state variables which are described in Appendix A.

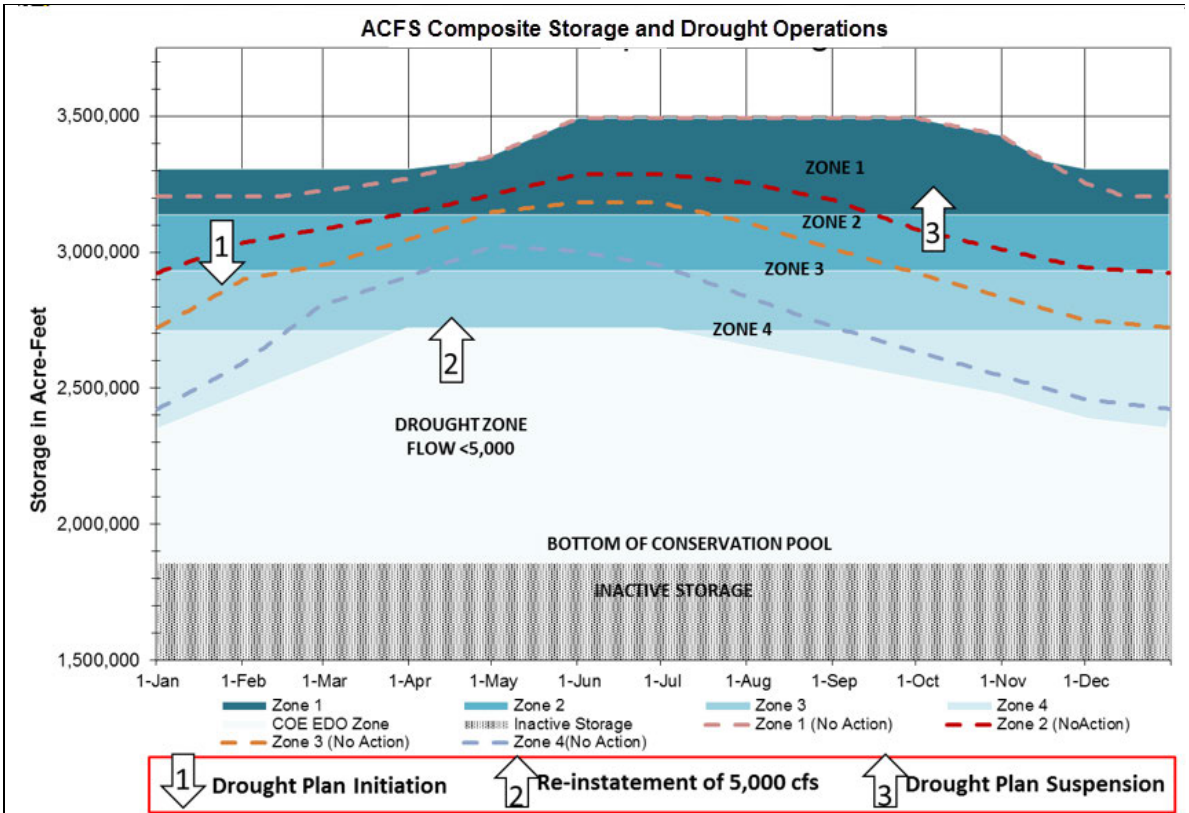


Figure 14. ACFS Composite Storage and Drought Operations

D. Minimum Flows

Minimum flow requirements for the ACFS alternative are the same as those in the NO Action alternative except for the addition of some minimum requirements at Columbus and two seasonal pulse flows below Jim Woodruff to support habitat in the Apalachicola River. These minimum flow requirments include:

1. ***Minimum 650 cfs Release from Buford***

2. ***Minimum 750 cfs Release for Peachtree Creek***

3. ***Minimum 670 cfs Release from West Point***

4. ***Minimum 1350 cfs daily and 1850 cfs weekly for Columbus***
   ACFS recommends that USACE include a flow control node in the upcoming update of the USACE's Water Control Manual which targets the 1350 cfs minimum daily flow and the 1850 cfs minimum weekly flow levels. A primary concern for the Columbus region is sustaining the flow levels that. are

included in the FERC license issued to the Georgia Power Company for the Middle Chattahoochee Hydropower Project. These flows at Columbus are 1350 cfs minimum daily flow and 1850 cfs minimum weekly flow. The flows meet both current and future needs for municipal water supply in the Columbus area based on the planning horizon of this plan. To ensure that these flows continue to be met, it is important to the water suppliers in the Columbus area that the USACE include a flow control node for Columbus.

Minimum daily release of 1350 cfs almost meet the weekly average of 1850 cfs ((1350*7)/5=1890). Therefore, only 1350 cfs minimum daily flow is applied to the model as shown in Figure 14.

5. ***Minimum 9000 cfs release from Jim Woodruff to occur for two weeks in May and July.*** ACFS recommended providing two pulsed water releases to achieve 9,000 cfs at Chattahoochee, FL for the last two weeks in May and July.

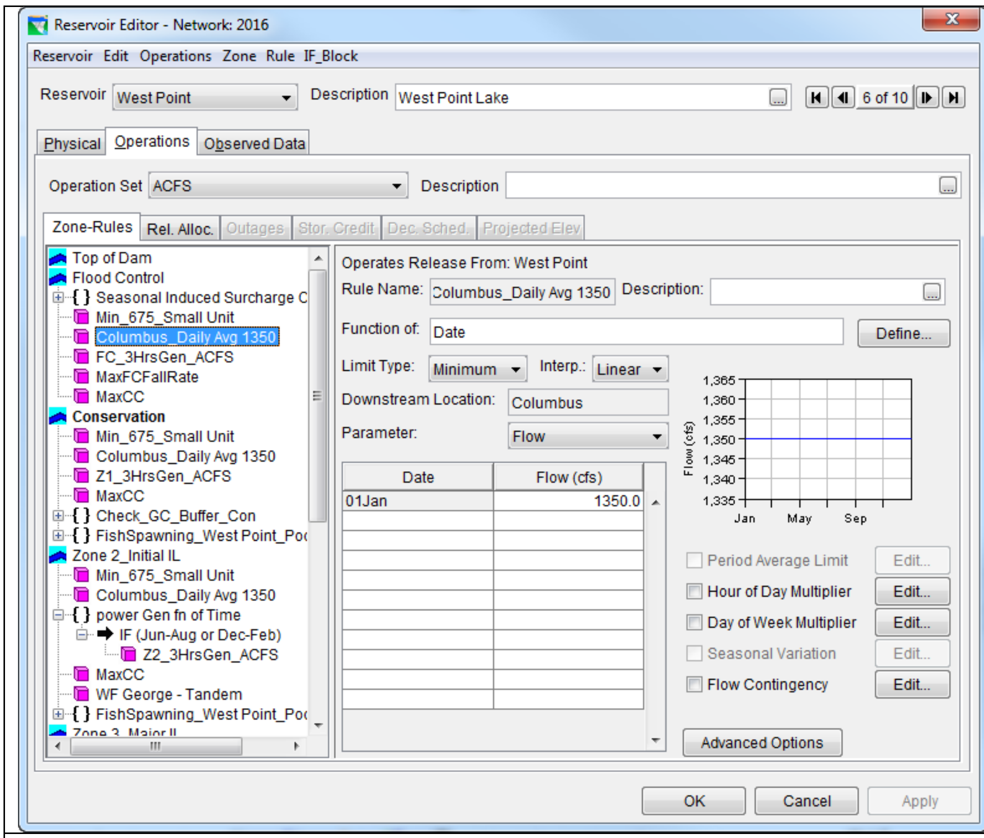


Figure 15. ACFS Columbus daily min flow

6. ***Suspend Ramping Rate after Pulse Flow***

The PDT in consultation with the USACE biologist determined that two environmental pulse flows needed to be paired with an appropriate falling ramp rate. A state variable, *Pulse_ACFs (*described in Appendix A), is used to activate the BI-Falling Ramp Rate rule when a pulse flow has been initiated. The conditional expression that uses this state variable is illustrated in Figure 16. Since the river rises quickly, there is little time for mussels to migrate upstream. Consequently, the pool may fall at the rate of the 1-day basin inflow until flow gets back to the value before pulse. The *MinRel_BaseFlow* rule shown in Figure 17 is a function of state variable that holds the flow at Chattahoochee before the pulse began.

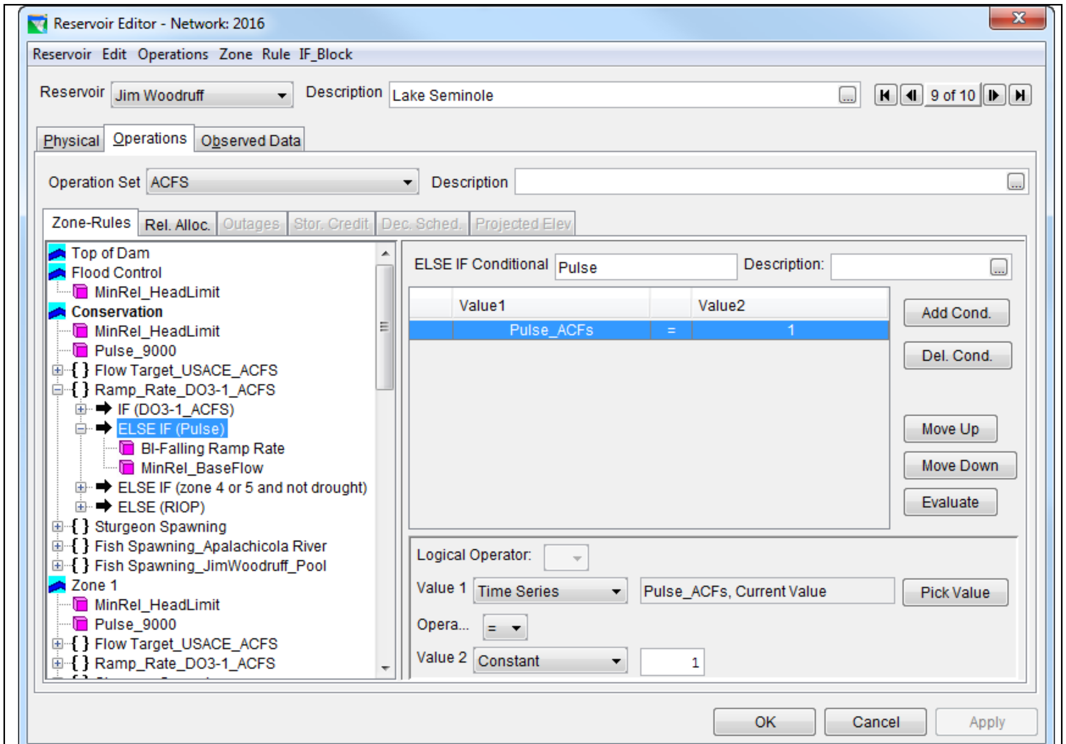


Figure 16. ACFS Pulse Flow-Suspend ramping rate

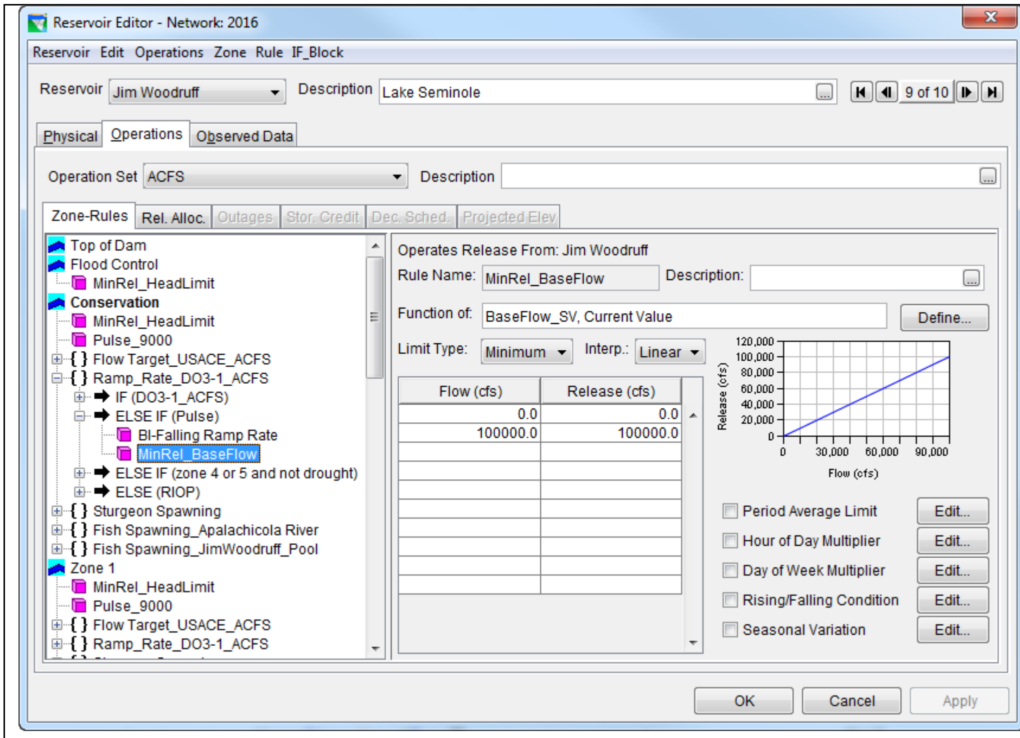


Figure 17. ACFS Pulse Flow- MinRel_BaseFlow rule

E. Navigation

ACFS alternative does not operate for navigation.

F. Fish and Wildlife

Fish and wildlife operation for ACFS alternative are the same as those in the NO-Action alternative described in ***sections III.A.2.a*** and section ***III.A.2.b*** of the June 2014 report.

G. Hydropower Operation

The ACFS recommended adjusting hydropower requirements to achieve more flexibility but provided no further guidance. In an effort to reflect the spirit of the recommendation, the PDT defined the ACFS hydropower generation be performed at each system reservoir as follows:

i. In action zone 1, releases for 3 hours of generation are made on weekdays.
ii. In action zone 2, releases for 3 hours of generation are made on weekdays in May-Sep and in Dec-Feb.

iii. Below action zone 2, hydropower generation is incidental and in conjunction with other project purposes. No releases are made only to meet a hydropower demand.

Figure 18, Figure 19, and Figure 20 show the ACFS hydropower operation at Buford at flood control, conservation, and zone 2 respectively. The same operation is applied at West Point and Walter F George.

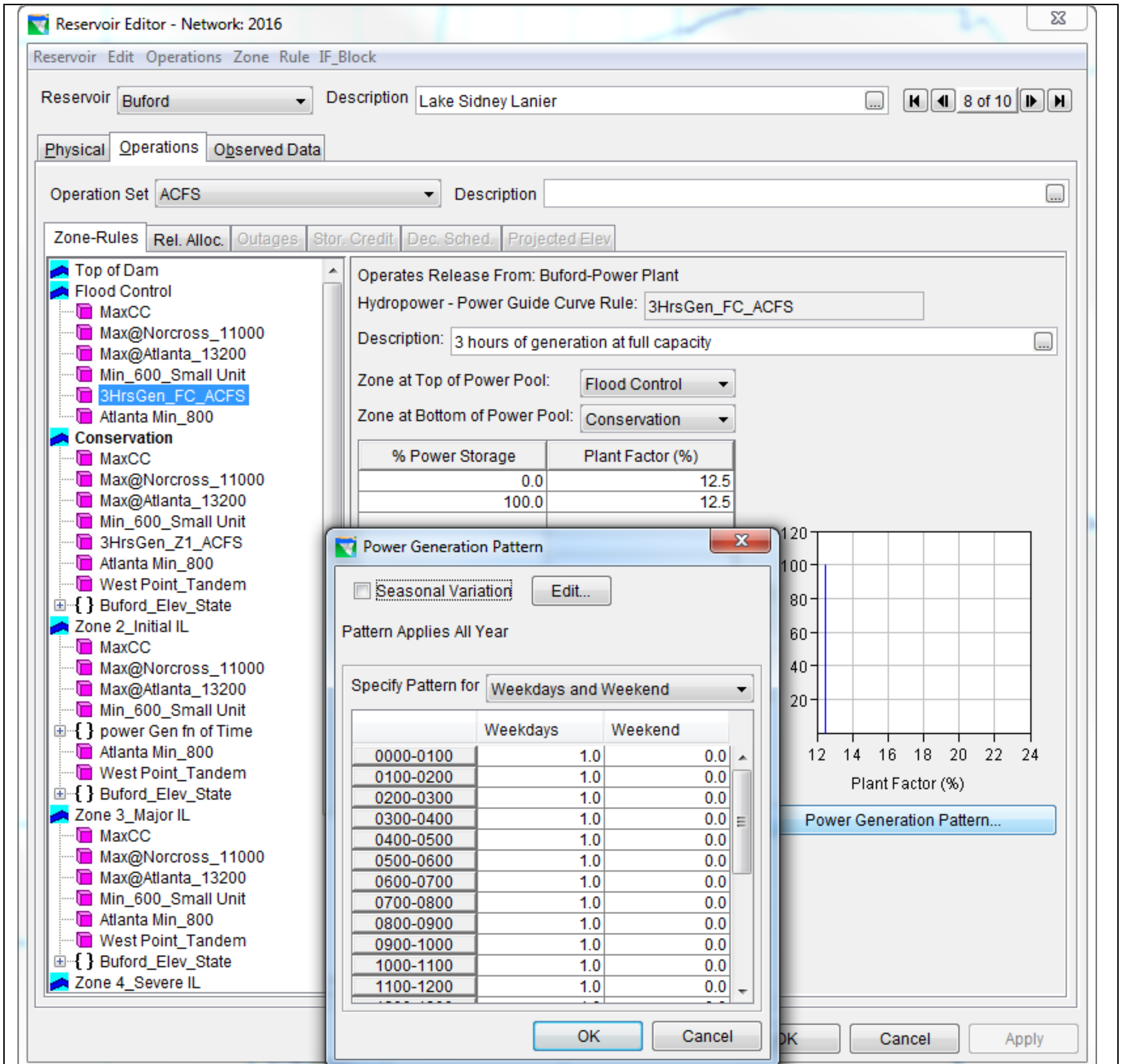


Figure 18. ACFS hydropower at Buford- Flood Control Zone

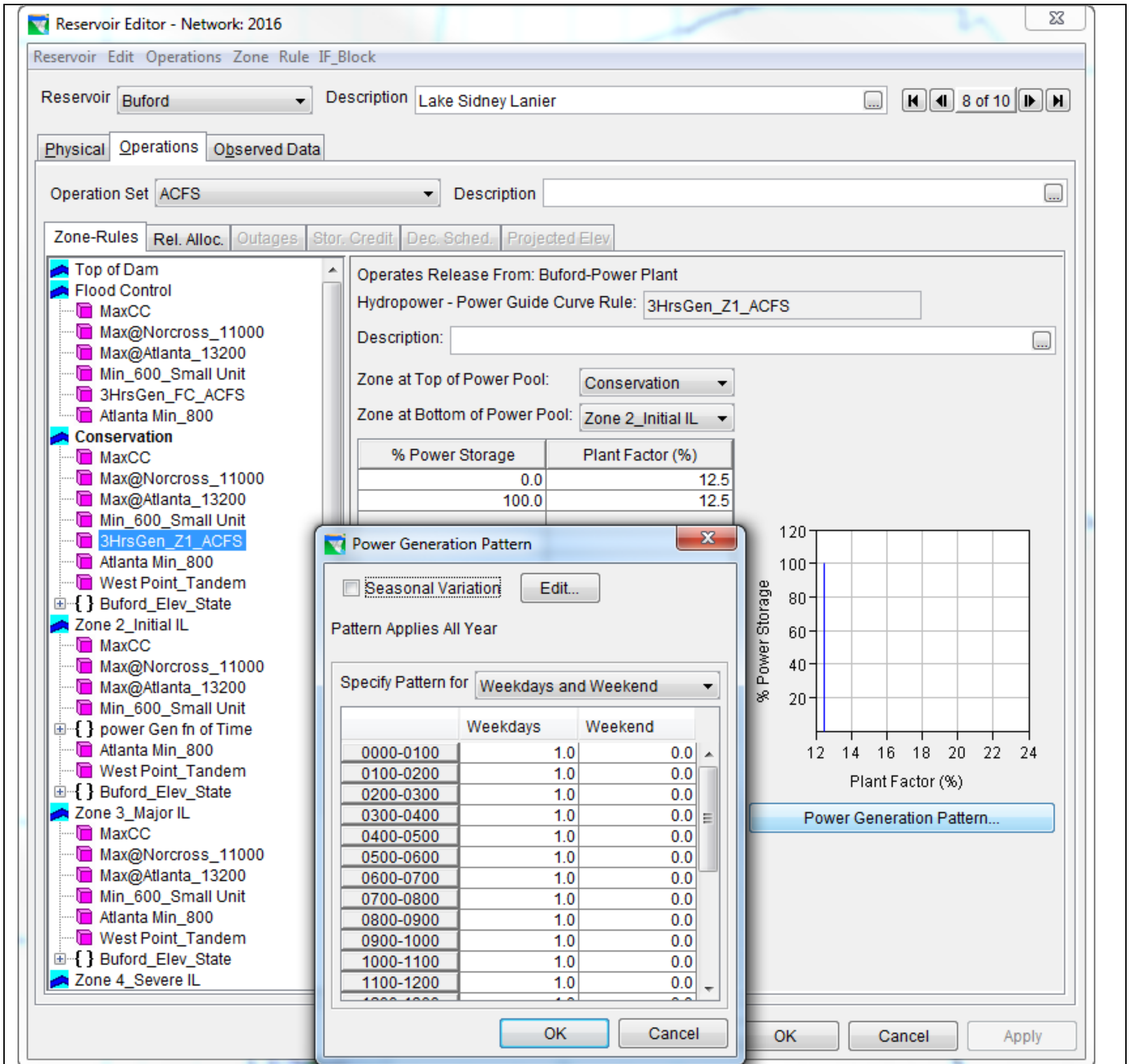


Figure 19. ACFS hydropower at Buford- Conservation Zone

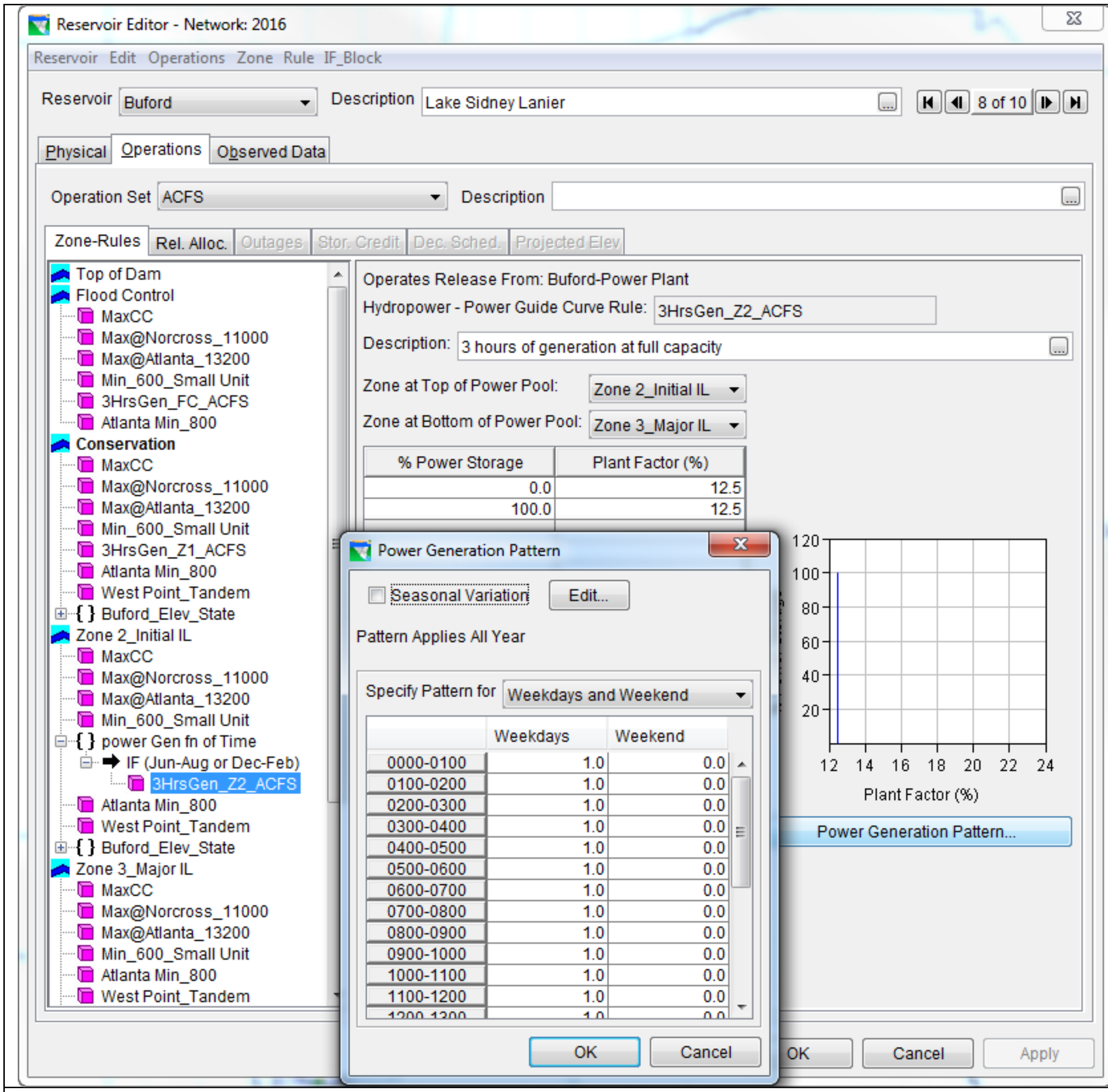


Figure 20. ACFS hydropower at Buford- Zone 2

H. Ramping Rate

The ACFS operation set suspends Ramping Rate the same as in the No Action alternative except that the drought plan is “triggered” when composite storage falls below the bottom of Zone 2 into Zone 3. Note: the composite storages are defined based on the ACFS Action Zones.

Also as described in *section IV.D.6* of this report, the ramping rate is suspended after pulse flow. Figure 21 shows the full ramping rate operation in the ACFS alternative.

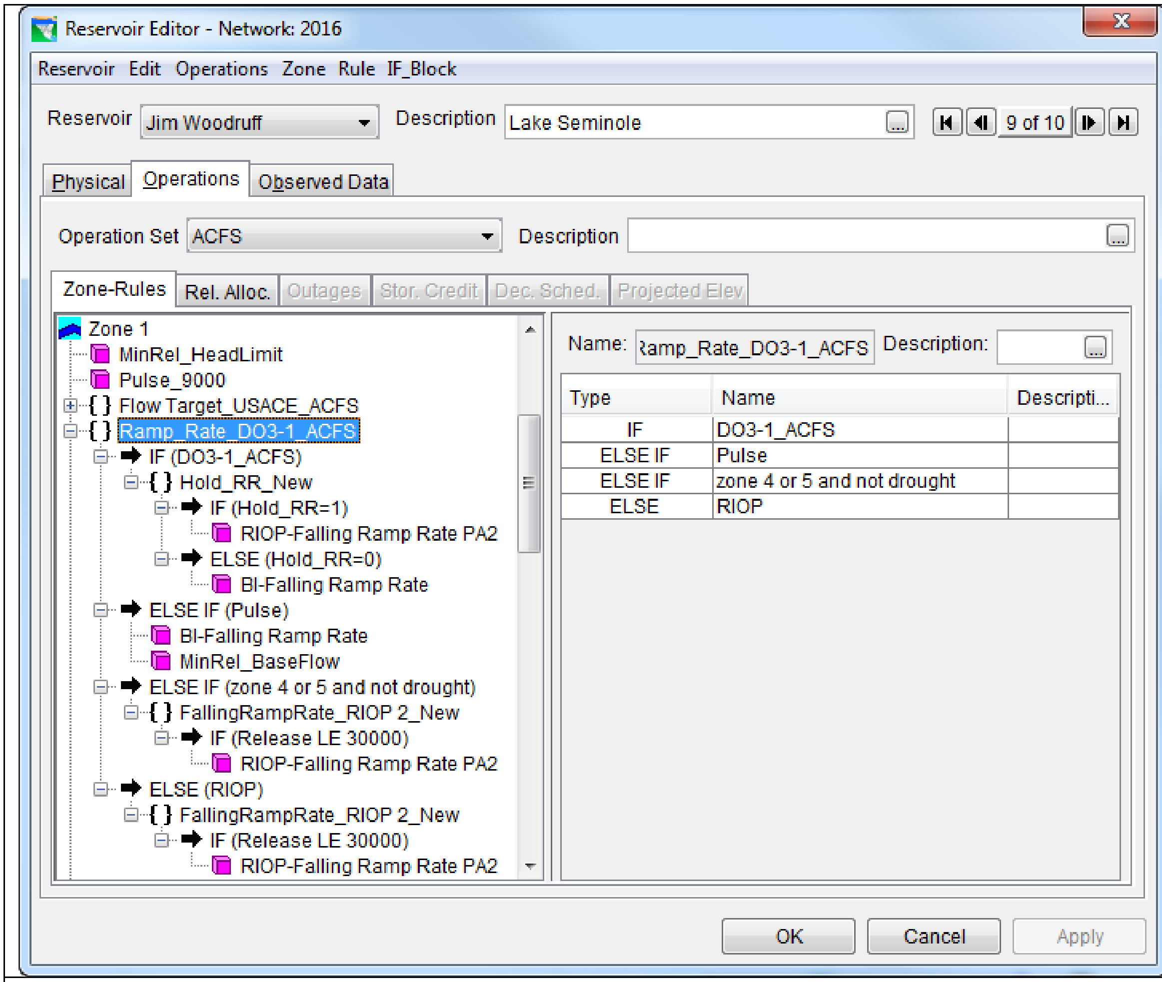
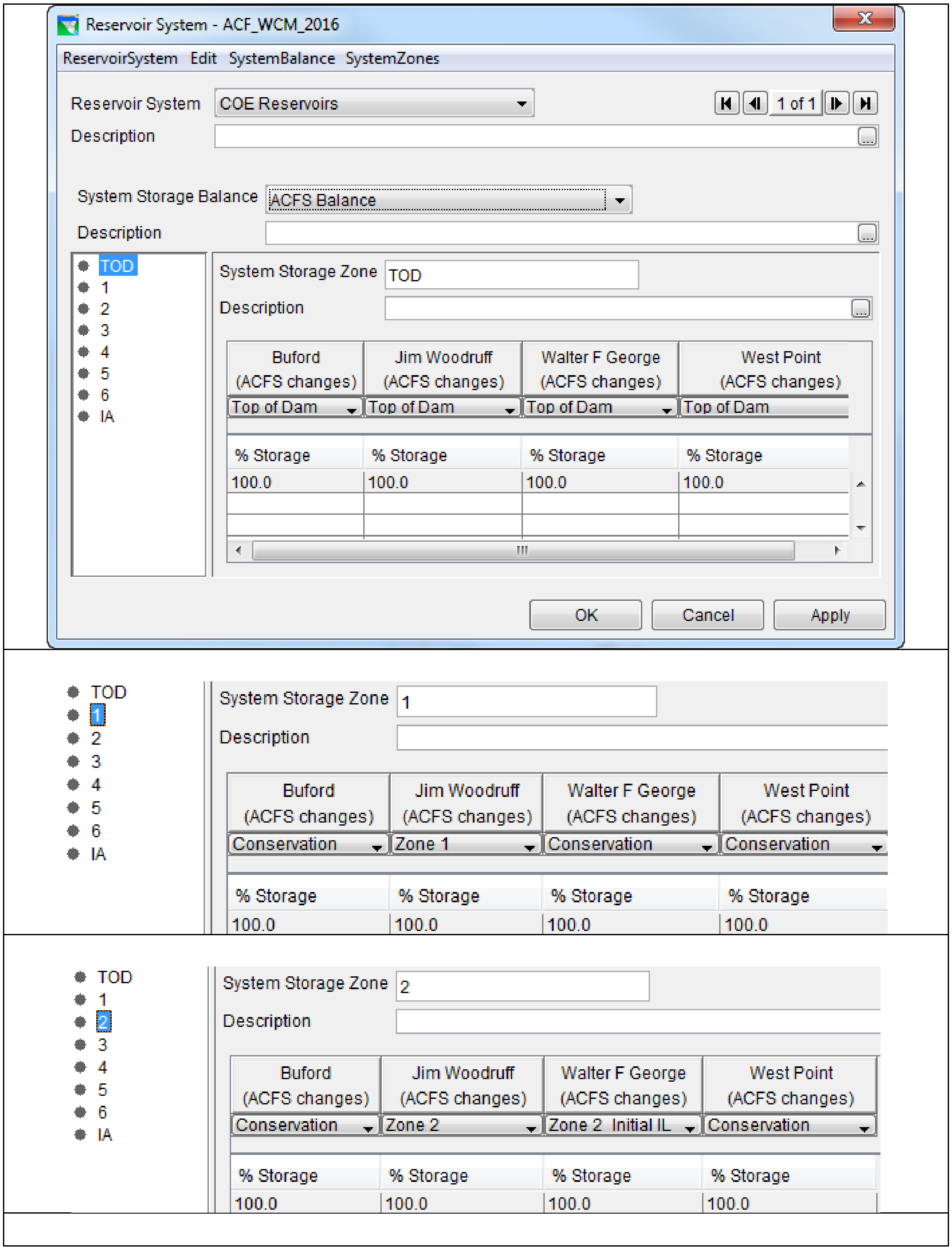


Figure 21. ACFS Ramping Rate

I. System Operation

The three large federal reservoirs in the ACF watershed, Buford, West Point andWalter F. George, and run-of-river Jim Woodruff, are viewed as a system in which each reservoir has its role to play. As described in section IV.B of this addendum, the ACFS alternative revised the action zones to coincide with the USACE reservoir recreational impact levels and then prescribed that the system balance operation would only release water from an upstream reservoir when the downstream reservoir is in a lower zone. This type of balance was accomplished in the ResSim model through the specification of a new storage balance definition encompassing the four Corps projects. Figure 22 shows the Reservoir System editor and the new explicit System Storage Balance named “ACFS Balance”. Tandem rules, guided by the system balance, are used in Buford and West Point to force releases from the upstream reservoir when the downstream reservoir is in a lower zone. The ACFS Balance and a tandem rule are also used at Walter F George to cause it to release from its Action Zones in the same level-by-level manner as in the other alternatives. In order to make the system balance operation work as intended, six system storage zones were specified in the System Balance definition. In addition a modeling technique was employed at West Point, Walter F George, and Jim Woodruff that involved dividing Zone 4 for into additional sub-zones so that the system balance definition had a reservoir zone that could be identified for each system balance zone. This concept is illustrated in Figure 22.



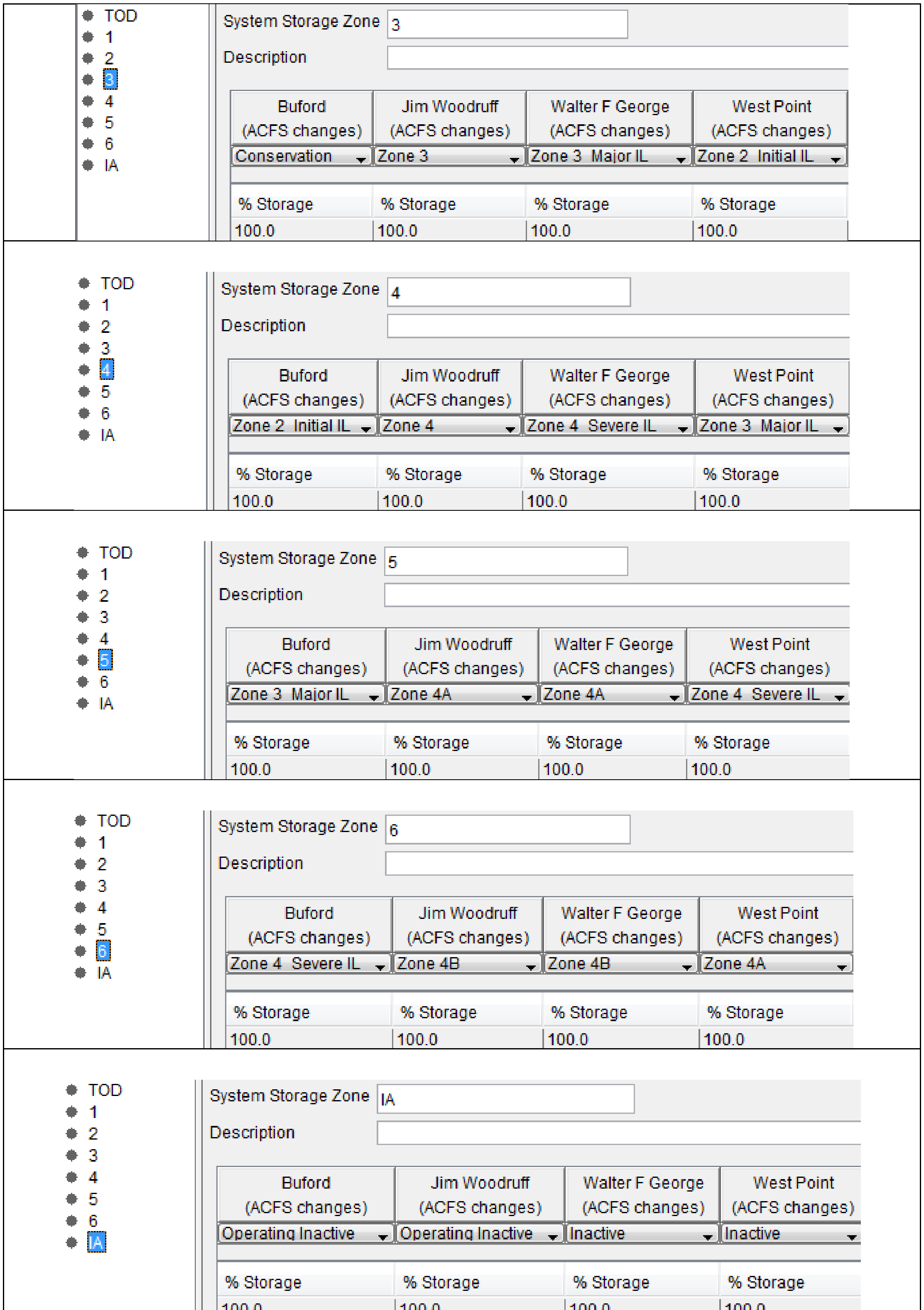


Figure 22. Reservoir System Balancing for ACFS Operation
Reservoir System=”COE Reservoirs”
System Storage Balance: ”ACFS Balance”

V. Results of Modeling

The watershed delivered with this addendum is named “ACF_WCM_2016_Final_052616”. It contains five simulations representing different groups of alternatives and analysis objectives. These simulations are listed and described in Table 5. The ACFS results shown in this section are taken from the “POR_ACFS Alternative” simulation and the Alt7_Opts KN results are taken from the “POR_New Alternatives_Build33” simulation.

Table 5. Combination of alternatives and water supply options

Simulation Name	Alternatives	Descriptions	Computed with HEC-ResSim build:
Climate Change Study_2016	A7K_CCQ1T1 A7K_CCQ2T1 A7K_CCQ3T1	This simulation covers Jan 1978-Dec 2008 and contains the three climate change alternatives. These alternatives use the 2016 network described in this addendum.	3.3.1.42
POR_ACFS Alternative	ACFS Alt1_OptBN Alt7_OptBN	This simulation covers the period of record, Jan 1939-Dec2011, and contains the ACFS alternative. For comparison purposes, the OptBN version of the Alt1 and Alt7 alternatives were included. All three alternatives use the 2016 network.	3.3.1.42
POR_Historic water use	Alt7_OptIH Alt7_OptKH Alt7_OptLH Alt7_OptMH Alt7_OptON Alt1_OptON	This simulation covers the period of record and contains Alt7 alternative run with the new water supply options I, K, L, & M and the historic water use data. Also included are Alt1 & Alt7 run with the new waters supply option O and current (2006) water use data. All six alternatives use the 2016 network.	3.3.1.40
POR_New Alternatives_Build 33	Alt7_OptAN Alt7_OptBN Alt7_OptIN Alt7_OptJN Alt7_OptKN Alt7_OptLN	This simulation covers the period of record and contains the Alt7 alternative run with water supply options A, B, I, J, K, L, & M and current (2006) water use data. Also	3.3.1.33

	Alt7_OptMN Alt1_OptAN Alt1_OptLN Alt7_OptHx	included are Alt1 alternative run with water supply options A & L and current water use data. These nine alternatives all use the 2016 network. For comparison purposes, the Alt7 alternative run with water supply option H and current water used data but using the 2014_OptH network was included. Computed with HEC-ResSim build 3.3.1.33	
Previous Alts_Build 33_New capacity curve	Alt1_OptBx Alt2_OptBx Alt3_OptBx Alt4_OptBx Alt5_OptBx Alt6_OptBx Alt7_OptBx	This simulation covers the period of record and contains Alt1 through Alt7 alternative run with water supply option B and current water use data. These seven alternatives use the 2014 network with the new Buford storage capacity curve.	3.3.1.33

Each simulated alternative produces daily results including reservoir releases, storage, and streamflow at all locations throughout the model. To assist with the analysis of so many results, custom plot and report generation scripts were created to provide on-demand illustrations and formatted output files of the state of various reservoir systems operations. Figure 23 shows the list of custom scripts used for plotting results and building reports. These scripts and instuctions for installing them are provided in the “Scripts_ToBeCopiedToUserArea” folder of the delivered watershed.

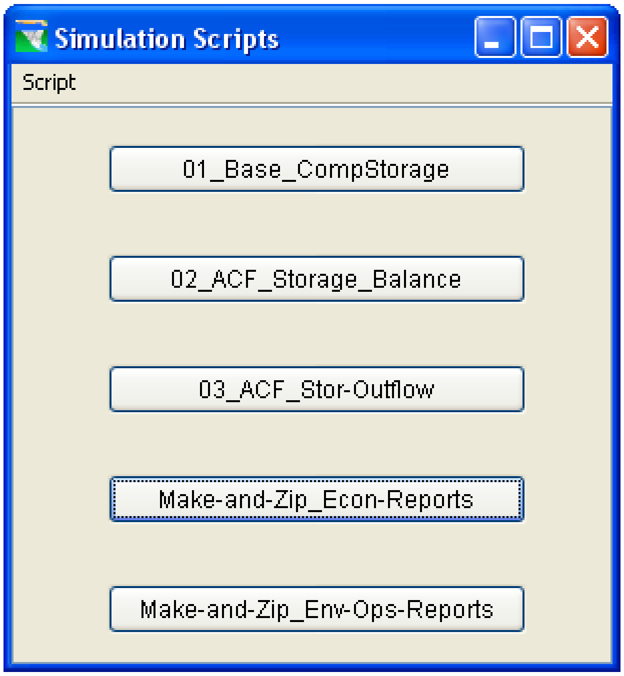


Figure 23. Simulation Scripts for Generating Plots and Reports

The "Base Composite Storage" plot script produces curves of the computed daily storages for Buford, West Point, and Walter F. George along with curves indicating the drought state and system zone. The Base Composite Storage plot for the Alt7_OptKN alternative is shown in Figure 24 and in Figure 25 for the ACFS alternative.

The "Storage Balance" plot script generates curves to illustrate the system storage balance by showing the current storage in each of the system projects as a percentage of its current action zone. This plot script also produces curves for outflow from Jim Woodruff and with its minimum release requirements. The Storage Balance plot for the Alt7_OptKN alternative is shown in Figure 26 and in Figure 27 for the ACFS alternative

The "Storage Outflow" plot script produces a viewport for each of the system reservoirs showing their operation zones and computed storages. The Storage Outflow plot for the Alt7_OptKN alternative is shown in Figure 28 and in Figure 29 for the ACFS alternative.

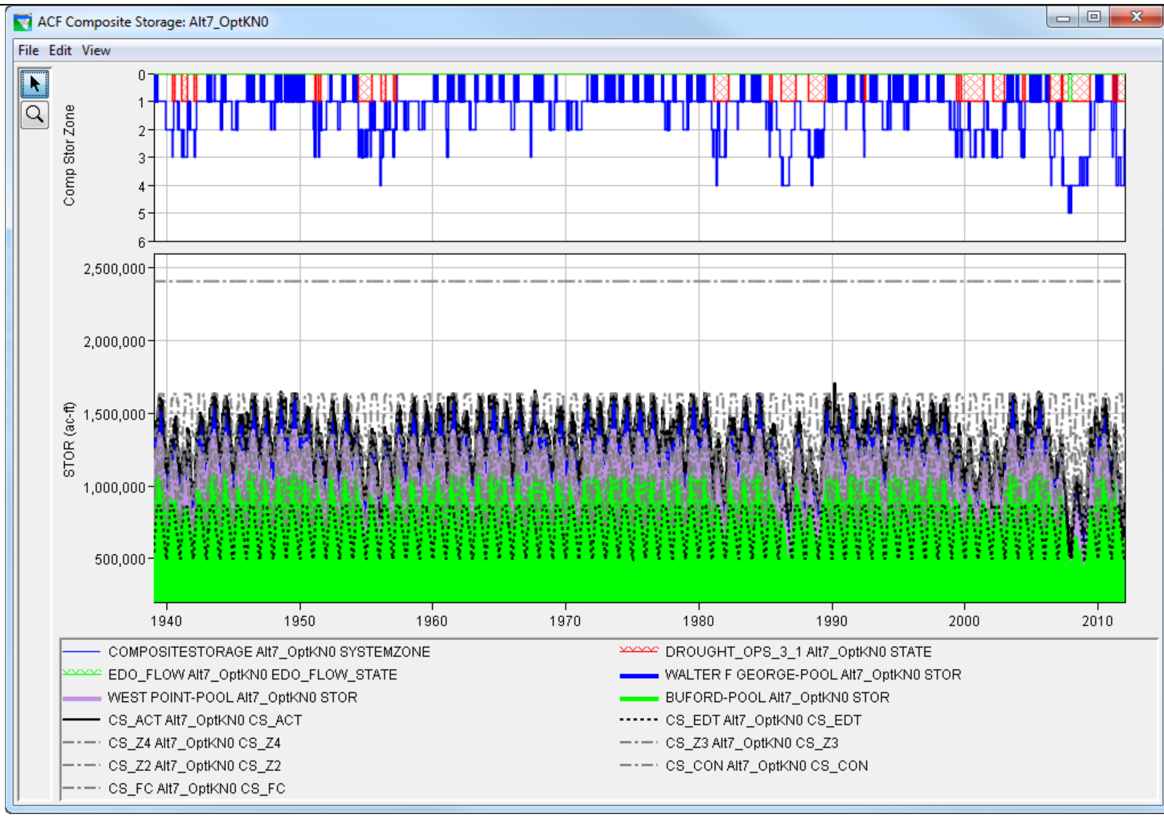


Figure 24. Scripted Plot: Base Composite Storage (POR Simulation, Alt7_OptKN Operations)

Figure 25. Scripted Plot: Base Composite Storage (POR Simulation, ACFS Operations)

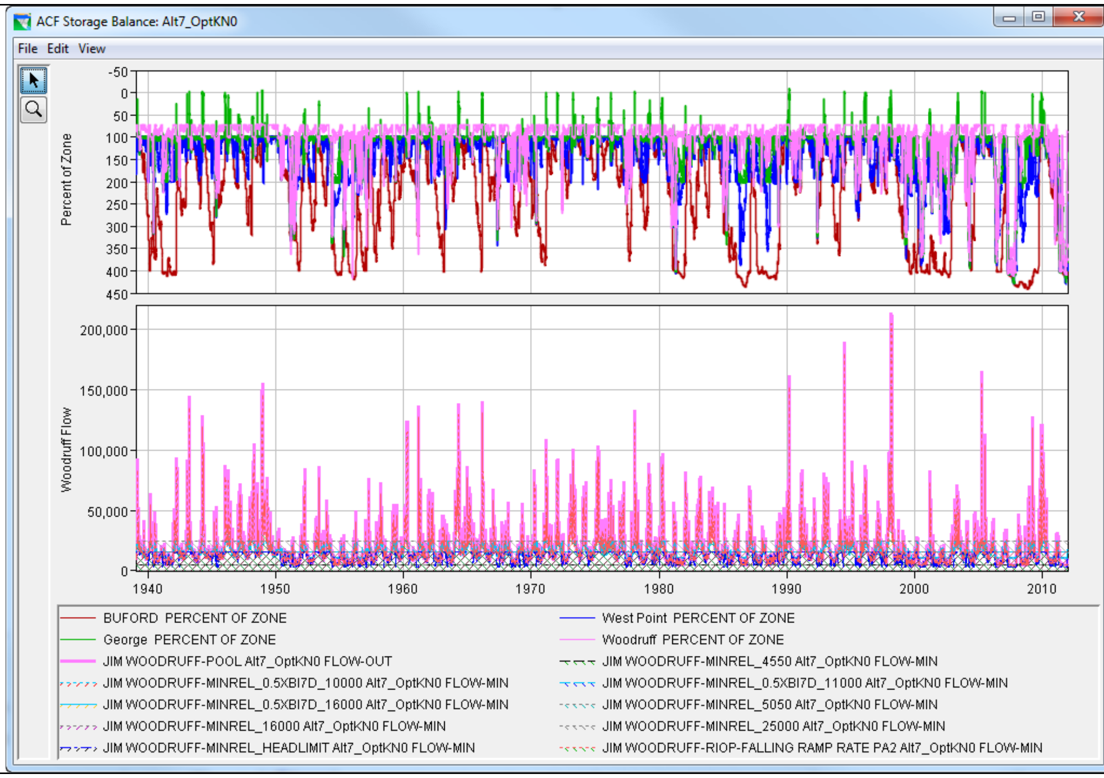


Figure 26. Scripted Plot: Storage Balance (POR Simulation, Alt7_OptKN Operations)

Figure 27. Scripted Plot: Storage Balance (POR Simulation, ACFS Operations)

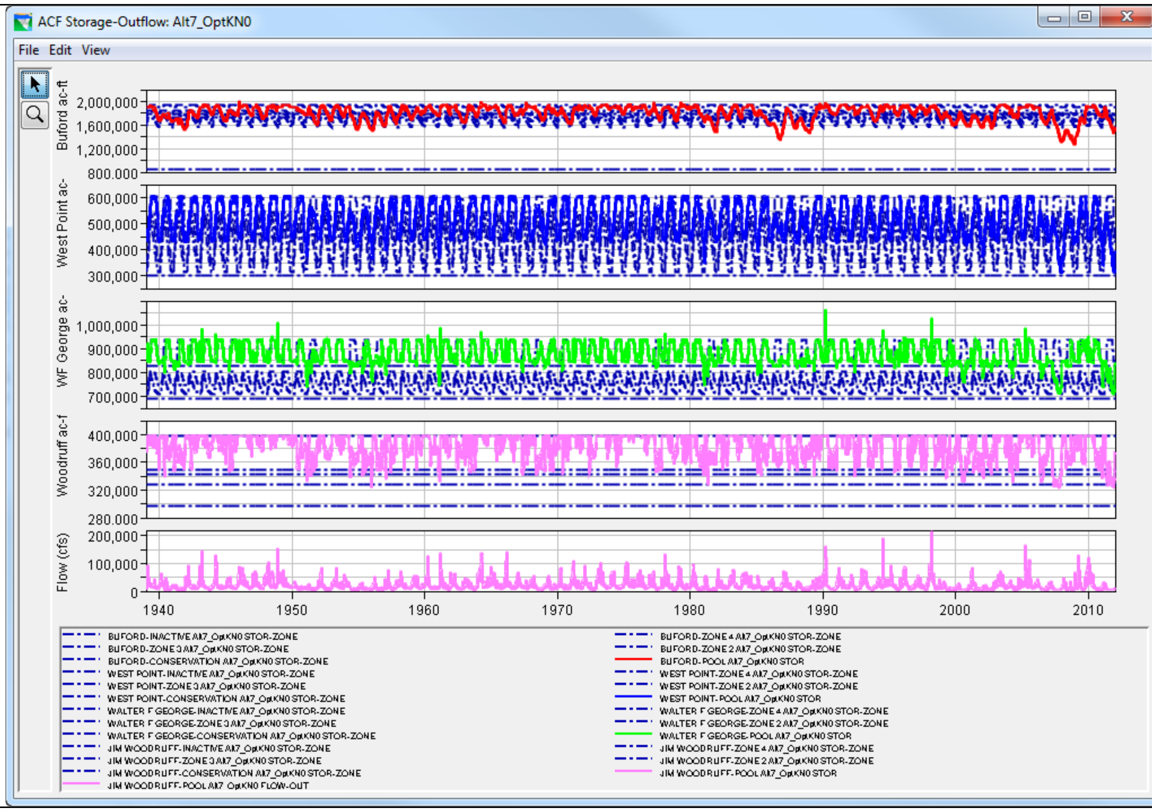


Figure 28. Scripted Plot: Storage Outflow (POR Simulation, Alt7_OptKN Operations)

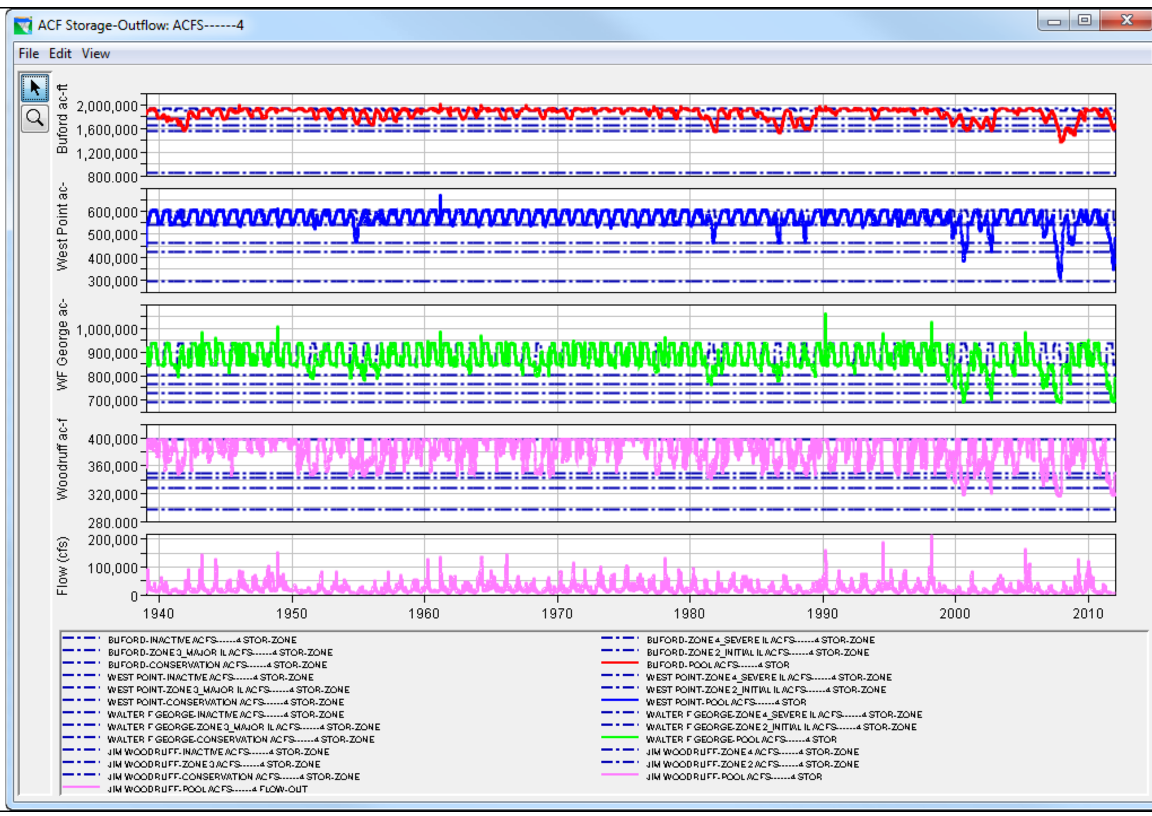


Figure 29. Scripted Plot: Storage Outflow (POR Simulation, ACFS Operations)

VI. References

USACE, Mobile District. *Apalachicola-Chattahoochee-Flint (ACF) Watershed. HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update. June* 2014.

VII. Appendix A – The *New* State Variable Scripts

A. CompositeStorage_ACFS

The CompositeStorage_ACFS state variable is the same as the CompositeStorage state variable described in ***section II.A.1 of Appendix H*** June 2014 report except that composite zone computations use the ACFS actions zones instead of the original action zones.

```
#####
##### 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))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	leapYears =  [ 1900,1904,1908,1912,1916,1920,1924,1928,1932,1936,1940,1944,1948,1952,1956,1960,
	1964,1968,1972,1976,1980,1984,1988,1992,1996,2000,2004,2008,2012,2016,2020,2024,2028,2032,2036,
	2040,2044,2048,2052,2056,2060,2064,2068,2072,2076,2080,2084,2088,2092,2096,2100,2104,2108,2112,
	2116,2120,2124,2128,2132,2136,2140,2144,2148,2152,2156,2160,2164,2168,2172,2176,2180,2184,2188,
	2192,2196,2200,2204,2208,2212,2216,2220,2224,2228,2232,2236,2240,2244,2248,2252,2256,2260,2264,
	2268,2272,2276,2280,2284,2288,2292,2296,2300 ]

	currentVariable.varPut("leapYears", leapYears)

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	#01Jan is day 1 in both leap and non-leap years
	#01Apr is day 91  in non-leap years and day 92  in leap years
	#01Jul is day 182 in non-leap years and day 183 in leap years
	#01Nov is day 305 in non-leap years and day 306 in leap years
	#04Dec is day 338 in non-leap years and day 339 in leap years
	#31Dec is day 365 in non-leap years and day 366 in leap years

	# Main inflection points that define the Exceptional Drought Trigger (EDT) curve
	# commented out lines reflect total composite storage
	# per JEH 9/26/2008...
	#	useable storage reflects subtraction of Inactive storage = 1,856,550 ac-ft
	EDT_nl_yr = [[1,91,182,305,338,365],
	#[ 495458,  864946, 864946,  621618,  530050,  497830] ]
	[2352008,2721496,2721496,2478168,2386600,2354380] ]
	EDT_l_yr =[ [1,92,183,306,339,366],
	#[ 495458,  864946, 864946,  621618,  530050,  497830] ]
	[2352008,2721496,2721496,2478168,2386600,2354380] ]

	currentVariable.varPut("EDT_nlyr", EDT_nl_yr)
	currentVariable.varPut("EDT_lyr", EDT_l_yr)

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

#from hec.script import Constants
#from hec.hecmath import DSS
```

```
#from hec.model import Interpolate
from hec.heclib.util import intContainer

# This state variable, called "CompositeStorage", determines in which
# Composite Storage Zone lies the Actual Composite Storage of the
# three-reservoir system (S. Lanier, W. Point, W.F. George)
# modified by Joan (Oct 2009, for speed and program enhancements)

# 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

# ---------------------------------------------------------------------------------------------------------------------
# Define Linear Interpolation and Lookup Functions
# ---------------------------------------------------------------------------------------------------------------------

# Linear Interpolation Function
def interpolate(x, x0, x1, y0, y1):
	y = y0 + (x - x0) * ( (y1-y0) / (x1-x0) )
	return y

# Lookup Function
def lookup(table, lookupVar):
	debugLevel = 1
	tabLen = len(table[0])
	if  table[0][0] >= lookupVar :
		# return first value
		returnVar = table[1][0]
		if table[0][0] > lookupVar and debugLevel == 6 :
			message = "CompositeStorage SV" + currentRuntimestep.dateTimeString() + "lookup elevation is outside table
limits; return value assumed to be the first value in the table"
			network.printLogMessage(message)
	elif table[0][-1] <= lookupVar:
		# return last value
		returnVar = table[1][-1]
		if table[0][-1] > lookupVar and debugLevel == 6 :
			message = "CompositeStorage SV" + currentRuntimestep.dateTimeString() + "lookup elevation is outside table
limits; return value assumed to be the last value in the table"
			network.printLogMessage(message)
	else:
		# lookupVar IS in the table, find the index of the first table value greater than lookupVar using a binary search

		lo = 0
		hi = tabLen-1
		while hi - lo > 1 :
			mid = (lo + hi) / 2
			if table[0][mid] > lookupVar :
				hi = mid
			else :
				lo = mid
		# now that we know where to look, interpolate for the return value (if necessary)
		if table[0][hi-1] == lookupVar :
			returnVar = table[1][hi-1]
		else:
			returnVar = interpolate(lookupVar, table[0][hi-1], table[0][hi], table[1][hi-1], table[1][hi])

	return returnVar
# ---------------------------------------------------------------------------------------------------------------------
#
#    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

#	print "performing composite storage calculation for step ", current_step, "  ", currentRuntimestep.dateTimeString()," PASS=",network.getComputePassCounter()

# Current storage each reservoir (Sidney Lanier, West Point, and Walter F. George)
	SL_STOR = network.getTimeSeries("Reservoir","Buford", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	WP_STOR = network.getTimeSeries("Reservoir","West Point", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	WG_STOR = network.getTimeSeries("Reservoir","Walter F George", "Pool", "Stor").getPreviousValue(currentRuntimestep)
	CS_Actual = SL_STOR + WP_STOR + WG_STOR

# Buford  (Lake Sidney Lanier) zone storages
	SL_TOD = network.getTimeSeries("Reservoir","Buford", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_FC = network.getTimeSeries("Reservoir","Buford", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_CON = network.getTimeSeries("Reservoir","Buford", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z2 =network.getTimeSeries("Reservoir","Buford", "Zone 2_Initial IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z3 =network.getTimeSeries("Reservoir","Buford", "Zone 3_Major IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_Z4 = network.getTimeSeries("Reservoir","Buford", "Zone 4_Severe IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	SL_IA = network.getTimeSeries("Reservoir","Buford", "Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)

# West Point  zone storages
	WP_TOD = network.getTimeSeries("Reservoir","West Point", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_FC = network.getTimeSeries("Reservoir","West Point", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_CON = network.getTimeSeries("Reservoir","West Point", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z2 = network.getTimeSeries("Reservoir","West Point", "Zone 2_Initial IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z3 = network.getTimeSeries("Reservoir","West Point", "Zone 3_Major IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_Z4 = network.getTimeSeries("Reservoir","West Point", "Zone 4_Severe IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WP_IA = network.getTimeSeries("Reservoir","West Point", "Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)

# Walter F. George zone storages
	WG_TOD = network.getTimeSeries("Reservoir","Walter F George", "Top of Dam", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_FC = network.getTimeSeries("Reservoir","Walter F George", "Flood Control", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_CON = network.getTimeSeries("Reservoir","Walter F George", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z2 = network.getTimeSeries("Reservoir","Walter F George", "Zone 2_Initial IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z3 = network.getTimeSeries("Reservoir","Walter F George", "Zone 3_Major IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_Z4 =network.getTimeSeries("Reservoir","Walter F George", "Zone 4_Severe IL", "Stor-ZONE").getPreviousValue(currentRuntimestep)
	WG_IA = network.getTimeSeries("Reservoir","Walter F George", "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
# ----------------------------------------------------------------------------------------------------------------------

# Current composite storage
	CS_Actual = SL_STOR + WP_STOR + WG_STOR
	network.getStateVariable("CS_ACT").setValue(currentRuntimestep, CS_Actual)

# Storage at Top of Dam zone
	CS_TOD = SL_TOD + WP_TOD + WG_TOD
	network.getStateVariable("CS_TOD").setValue(currentRuntimestep, CS_TOD)

# Storage at top of Flood Control zone
	CS_FC = SL_FC + WP_FC + WG_FC
	network.getStateVariable("CS_FC").setValue(currentRuntimestep, CS_FC)
```

```
# system Zone 1
    CS_CON = SL_CON +WP_CON + WG_CON
    network.getStateVariable("CS_CON").setValue(currentRuntimestep, CS_CON)

# system Zone 2
    CS_Z2 =  SL_Z2 +WP_Z2 + WG_Z2
    network.getStateVariable("CS_Z2").setValue(currentRuntimestep, CS_Z2)

# system Zone 3
    CS_Z3 = SL_Z3 + WP_Z3 + WG_Z3
    network.getStateVariable("CS_Z3").setValue(currentRuntimestep, CS_Z3)

# system Zone 4
    CS_Z4 = SL_Z4 + WP_Z4 + WG_Z4
    network.getStateVariable("CS_Z4").setValue(currentRuntimestep, CS_Z4)

# system Zone 5
    CS_IA = SL_IA + WP_IA + WG_IA
    network.getStateVariable("CS_IA").setValue(currentRuntimestep, CS_IA)



# Storage at top of Exceptional Drought Trigger (EDT) Zone

    leapYears = currentVariable.varGet("leapYears")
    EDT_nl_yr = currentVariable.varGet("EDT_nlyr")
    EDT_l_yr = currentVariable.varGet("EDT_lyr")

    day = currentRuntimestep.getHecTime().dayOfYear()
    year = currentRuntimestep.getHecTime().year()
    if year in leapYears:
        EDT_table = EDT_l_yr
    else:
        EDT_table = EDT_nl_yr

    CS_EDT = lookup(EDT_table,day)
    network.getStateVariable("CS_EDT").setValue(currentRuntimestep, CS_EDT)

# -----------------------------------------------------------------------------------------------------------------------
# Check 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             State
#      ----------    ----------
#      Above Con.    0
#      Zone 1(Con)   1
#      Zone 2          2
#      Zone 3          3
#      Zone 4          4
#      EDT              5
#
    if CS_Actual > CS_CON :
        CS_state = 0
    elif  CS_Actual > CS_Z2 :
        CS_state = 1
    elif  CS_Actual > CS_Z3 :
        CS_state = 2
    elif  CS_Actual > CS_Z4 :
        CS_state = 3
    elif  CS_Actual > CS_EDT :
        CS_state = 4
    else :
        CS_state = 5

    currentVariable.setValue(currentRuntimestep, CS_state)
```

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

from hec.script import Constants
#
# 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()
```

B. Drought_Ops_3_1_ACFS

The Drought_Ops_3_1_ACFS state variable is the same as Drought_Ops_3_1 state variable described in ***section II.A.2 of Appendix H*** June 2014 report except that it uses the CompositeStorage_ACFS state variable.

```
#####
##### 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 state variable, called "Drought_Ops_3_1", determines at the beginning of every month whether or
# not the system's Composite Storage is within the drought zones, or the Exceptional Drought Trigger zone.
# The drought operation is turned on when the composite storage falls into Composite Zone 3 and
# remains in effect until the composite storage returns to composite storage Zone 1.

# “Hold_RR” and “Min_reached” slave sttae variables are used to maintain the RIOP-Falling Ramp Rate rule when
# Drought operation first occurs until the target # minimum flow is reached, at which point the RIOP-Falling
# Ramp Rate is suspended.  The target minimum flow # is 5050 cfs during Drought Operation (DO) and 4550 cfs
# during Exceptional Drought Operation (EDO).

from hec.script import Constants

#Buffer is a parameter to adjust the trigger for resuming RR after a temporarily suspension (unit=cfs)
Buffer=200
# ------------------------------------------------------------------------------------------------------------------------
# Read input state variable time series & value @ current run time step
# ------------------------------------------------------------------------------------------------------------------------

CS_state = network.getStateVariable("CompositeStorage_ACFS").getValue(currentRuntimestep)

JWD_Q_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
JWD_Q_prev=JWD_Q_TS.getPreviousValue(currentRuntimestep)
JWD_Q_prev2=JWD_Q_TS.getLaggedValue(currentRuntimestep, 2)

#message =  "\n\n\n" + currentRuntimestep.dateTimeString() + "\tCompositeStorage " + `CS_state`
#network.printLogMessage(message)

DOps_state_prev = currentVariable.getPreviousValue(currentRuntimestep)

EDOflowSV = network.getStateVariable("EDO_Flow")
EDOflow_prev = EDOflowSV.getPreviousValue(currentRuntimestep)

Hold_RR_SV = network.getStateVariable("Hold_RR")
Hold_RR_prev = Hold_RR_SV.getPreviousValue(currentRuntimestep)
```

```
Min_Reached_SV=network.getStateVariable("Min_Reached")
Min_Reached_prev=Min_Reached_SV.getPreviousValue(currentRuntimestep)

# ------------------------------------------------------------------------------------------------------------------------
# Check the Composite Storage State at the Beginning of every month
# ------------------------------------------------------------------------------------------------------------------------

mon = currentRuntimestep.getHecTime().month()
day = currentRuntimestep.getHecTime().day()
hour = currentRuntimestep.getHecTime().hour()

#message =  currentRuntimestep.dateTimeString() + "\tmon " + `mon`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\tday " + `day`
#network.printLogMessage(message)
#message =  currentRuntimestep.dateTimeString() + "\thour " + `hour`
#network.printLogMessage(message)

from hec.model import RunTimeStep
prevRTS=RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon=prevRTS.month()
curStepMon=currentRuntimestep.month()
#print "prevMon, curMon = ", prevStepMon, curStepMon

#-------------------------------------------------------------------------------------------
#if first of the month
if (prevStepMon<>curStepMon):
	if  ( CS_state == 3):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	elif  ( CS_state == 4):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	elif (CS_state == 5):
		DOps_state = Constants.TRUE
		EDOflow = Constants.TRUE
	elif (DOps_state_prev and CS_state == 2):
		DOps_state = Constants.TRUE
		EDOflow = Constants.FALSE
	else:
		DOps_state = Constants.FALSE
		EDOflow = Constants.FALSE

	# If Feb is in drought, drought ops is extended to March.
	if (DOps_state_prev and prevStepMon==2):
		DOps_state = Constants.TRUE

# Is the DO new
	if	DOps_state:
		if not DOps_state_prev:
		#DO is new
			Hold_RR = Constants.TRUE
			Min_Reached=0
			#override Min_reached_prev to an appropriate value to use if we get an immediate ramp rate suspension(In the any
day suspension check)
			Min_Reached_prev=JWD_Q_prev2

		elif EDOflow and not EDOflow_prev:
		#EDO is new
			if not Hold_RR_prev and Min_Reached_prev==0:
			# if we are not in suspension, reactivate Hold_RR
				Hold_RR = Constants.TRUE
				Min_Reached=JWD_Q_prev
			elif Hold_RR_prev:
				Hold_RR = Constants.TRUE
				if JWD_Q_prev<Min_Reached_prev:
					Min_Reached=JWD_Q_prev
				else:
```

```
                        Min_Reached=Min_Reached_prev
                else:
                #we are in suspension, maintain suspension, and decide in any day section below
                    Hold_RR = Constants.FALSE
                    Min_Reached=Min_Reached_prev

            elif Hold_RR_prev:
            #DO is not new , check if RR still holds
                Hold_RR = Constants.TRUE
                Min_Reached=Min_Reached_prev

            elif not Hold_RR_prev and Min_Reached_prev>0:
            # we are in suspension
                Hold_RR = Constants.FALSE
                Min_Reached=Min_Reached_prev

        else:
        # Not DO
            Hold_RR = Constants.FALSE
            Min_Reached=Min_Reached_prev
#-------------------------------------------------------------------------------------
#else other days in the month
else:
    DOps_state=DOps_state_prev
    EDOflow= EDOflow_prev

    Hold_RR = Hold_RR_prev
    Min_Reached=Min_Reached_prev

#-------------------------------------------------------------------------------------
#-------------------------------------------------------------------------------------
#Any day of the month and check for suspending Hold_RR
if DOps_state:
    if Hold_RR:
    #have we reached our target Min(4550 or 5050)?
        if EDOflow:
            if JWD_Q_prev>4550:
                Hold_RR = Constants.TRUE
                if JWD_Q_prev<Min_Reached_prev:
                    Min_Reached=JWD_Q_prev
                else:
                    Min_Reached=Min_Reached_prev
            else:
                Hold_RR = Constants.FALSE
                Min_Reached=0
        else:
            if JWD_Q_prev>5050:
                Hold_RR = Constants.TRUE
                if JWD_Q_prev<Min_Reached_prev:
                    Min_Reached=JWD_Q_prev
                else:
                    Min_Reached=Min_Reached_prev
            else:
                Hold_RR = Constants.FALSE
                Min_Reached=0

    #Is the release rising?(Do we need to suspend?) and DO is not new
    if Hold_RR:
        if DOps_state_prev:
            if (JWD_Q_prev2<JWD_Q_prev):
                Hold_RR = Constants.FALSE
                Min_Reached=Min_Reached_prev

    # Is the Hold_RR suspended?
    else:
        if Min_Reached>0:
            #Reach the min limit+Buffer
            if JWD_Q_prev<Min_Reached_prev+Buffer:
                #resume Hold_RR
                Hold_RR = Constants.TRUE
```

```
                if JWD_Q_prev<Min_Reached_prev:
                    Min_Reached=JWD_Q_prev
                else:
                    Min_Reached=Min_Reached_prev
            else:
                #maintain suspension
                Min_Reached=Min_Reached_prev
                Hold_RR = Constants.FALSE
else:
    Hold_RR = Constants.FALSE
    Min_Reached=0

#message =  currentRuntimestep.dateTimeString() + "\tDOps_state " + `DOps_state` + "current value\n"
#network.printLogMessage(message)

EDOflowSV.setValue(currentRuntimestep,EDOflow)
Hold_RR_SV.setValue(currentRuntimestep,Hold_RR)
Min_Reached_SV.setValue(currentRuntimestep,Min_Reached)
currentVariable.setValue(currentRuntimestep, DOps_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...
```

C. Pulse_ACFS

The use of this state variable is shown in ***section IV.D.5*** of this report. It checks to determine if the pulse release of 9,000 cfs at Chattahoochee, FL was initiated on May 15 and July 15. The pulse considered "initiated" if the flow on the 14th is less than 9000 cfs. If initiated, then a flag is set to trigger the *BI-FallingRampRate* rule rather than the more restrictive *FallingRampRate_RIOP 2_New rule* and the release rate that was made before the pulse flow began is stored and later used to return the ramp rate rule to return to normal.

```
#####
##### 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.

	currentVariable.localTimeSeriesNew("Pulse_TS")
	currentVariable.localTimeSeriesNew("BaseFlow")
	currentVariable.localTimeSeriesNew("Day")
	currentVariable.localTimeSeriesNew("JW_Prev")

	return Constants.TRUE
#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####


# This state variable checks to determine if the pulse release of 9,000 cfs at Chattahoochee, FL was initiated on May 15 and July
15.
# The pulse considered "initiated" if the flow on the 14th is less than 9000 cfs.  If initiated, then a flag is set to trigger the
# BI-FallingRampRate rule rather than the more restrictive FallingRampRate_RIOP 2_New rule and the release rate that was made
before
# the pulse flow began is stored and later used to return the ramp rate rule to return to normal.

Pulse_Flow=9000

curmonth=currentRuntimestep.month()
curday=currentRuntimestep.getHecTime().day()-1

Day_TS=currentVariable.localTimeSeriesGet("Day")
Day_TS.setCurrentValue(currentRuntimestep,curday)

Pulse_TS=currentVariable.localTimeSeriesGet("Pulse_TS")

BaseFlow_SV = network.getStateVariable("BaseFlow_SV")

BaseFlow_TS=currentVariable.localTimeSeriesGet("BaseFlow")
BaseFlow=BaseFlow_TS.getPreviousValue(currentRuntimestep)

JW_Flow_Prev=network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT").getPreviousValue(currentRuntimestep)

JW_Flow_Prev_TS=currentVariable.localTimeSeriesGet("JW_Prev")
JW_Flow_Prev_TS.setCurrentValue(currentRuntimestep,JW_Flow_Prev)
```

```
# check if the day is May 15th or Jul 15th
if (curmonth==5 or curmonth==7) and curday==15:
	# check if flow on the 14th is less than Pulse_Flow(9000 cfs)
	if JW_Flow_Prev <= Pulse_Flow:
		# Need to do a pulse and store the flow
		Pulse=1
		BaseFlow=JW_Flow_Prev
	else:
		Pulse=0
	PulseRR=0
else:
	Pulse=Pulse_TS.getPreviousValue(currentRuntimestep)

	if Pulse==1:
		if JW_Flow_Prev<=BaseFlow+1:
			# Do not pluse and reset the Pulse to zero
			PulseRR=0
			Pulse=0
		else:
			PulseRR=1
	else:
		PulseRR=0

BaseFlow_SV.setValue(currentRuntimestep,BaseFlow)
BaseFlow_TS.setCurrentValue(currentRuntimestep,BaseFlow)
Pulse_TS.setCurrentValue(currentRuntimestep,Pulse)

currentVariable.setValue(currentRuntimestep,PulseRR)
#####
##### 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
currentVariable.localTimeSeriesWriteAll()
```

Appendix F

ACF Basin Critical Yield Report

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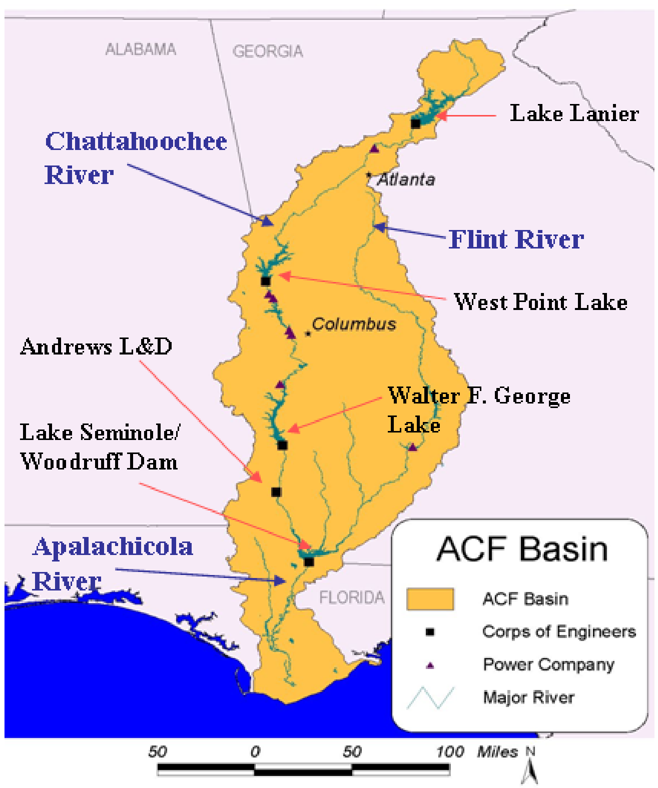
US Army Corps
of Engineers®
Mobile District

FEDERAL STORAGE RESERVOIR CRITICAL YIELD ANALYSES

APALACHICOLA-CHATTAHOOCHEE-FLINT (ACF) RIVER BASIN



April 2015

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Appendix A - Critical Yield Methodology

LIST OF FIGURES

LIST OF TABLES

Appendix B – Apalachicola-Chattahoochee-Flint (ACF) Basin Detailed Analysis

TITLE	**PAGE NUMBER**

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF TABLES

Appendix C – Prior Reports and References

TITLE

LIST OF TABLES

TABLE **DESCRIPTION**

Appendix D – Drought Description

TITLE **NUMBER**

Appendix E – Buford Dam Area Capacity Comparison

FIGURE **DESCRIPTION**

FEDERAL STORAGE RESERVOIR
CRITICAL YIELD ANALYSIS

EXECUTIVE SUMMARY

Apalachicola-Chattahoochee-Flint River Basin

SCOPE AND PURPOSE

The Federal Storage Reservoir Critical Yield Analysis, Apalachicola-Chattahoochee-Flint (ACF) Basin (Critical Yield Report) provides information and technical analysis in response to Congressional direction in reports accompanying the Energy and Water Development and Related Agencies Appropriations Act, 2010 (H.R. 3183; Public Law 111-85) which includes the following language:

"*Alabama-Coosa-Tallapoosa [ACT], Apalachicola-Chattahoochee- Flint [ACF] Rivers, Alabama, Florida, and Georgia.—The Secretary of the Army, acting through the Chief of Engineers, is directed to provide an updated calculation of the critical yield of all Federal projects in the ACF River Basin and an updated calculation of the critical yield of all Federal projects in the ACT River Basin within 120 days of enactment of this Act*."

Pursuant to this language, the U.S. Army Corps of Engineers (Corps), Mobile District and Hydrologic Engineering Center (HEC), developed updated critical yields for the Federal projects in the ACF Basin in February 2010. This analysis is an update, to the February 2010 critical yield analysis, for the purposes of the WCM update and WSSA for Lake Sidney Lanier.

Federal reservoirs in the ACF Basin that are included in this analysis are Lake Sidney Lanier, West Point Lake, and Walter F. George Reservoir (reference Figure 1), because they hold the majority of water storage on the ACF System. George Andrews Lock and Dam and Jim Woodruff Lock and Dam (Lake Seminole) are Federal projects on the ACF System that are excluded from the critical yield analysis because these projects are 'run of river' impoundments with little or no usable water storage, and cannot significantly contribute to critical yield. In addition, two proposed non-federal water storage reservoirs, Glades and Bear Creek, are analyzed for their individual expected yield and potential impact on existing projects.

Detailed critical yield analysis for the ACF Basin is presented in the appendices.

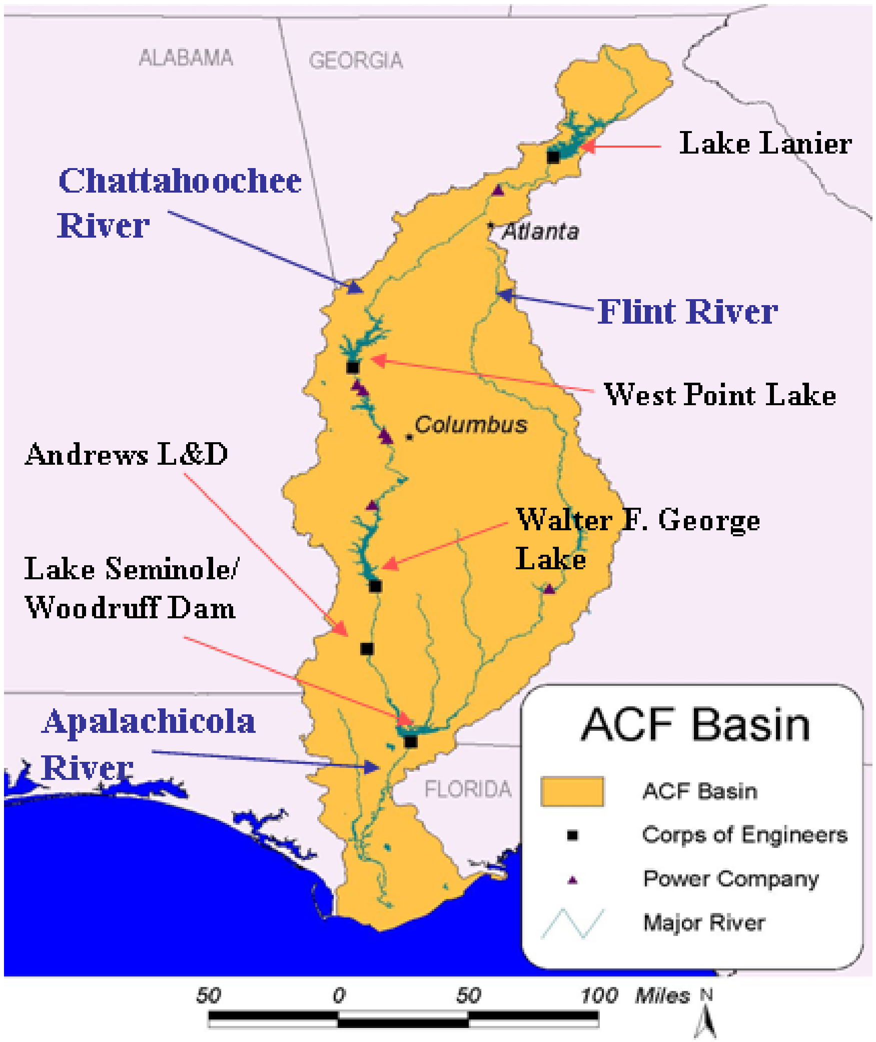


Figure 1. Federal Reservoir Projects in the ACF Basin

CRITICAL YIELD

Critical yield is the maximum flowrate that can be continuously removed from a reservoir through releases from the dam and/or withdrawals from the reservoir, even during the most severe drought in the period of record (1939-2012), while completely (and exactly) depleting the reservoir conservation storage. Conservation storage is the amount of water available in a reservoir to meet project purposes other than flood control. . The Corps cannot guarantee critical yield will always be available because future droughts may be worse than droughts of the period of record, requiring more conservative regulation of reservoirs. Critical yield has been previously referred to as prime flow.

Critical yield is important because it is the basis from which water stored in a reservoir is allocated to various project purposes. The amount or volume of water stored in a reservoir can be allocated to a specific project purpose, such as hydropower or water supply, based on a percent of critical yield. A change in critical yield could result in modifications of the allocations for a project purpose.

Critical yield can be expressed in cubic feet of water per second (cfs), but can be expressed in any other reasonable flow rate units representing the rate at which water can be removed. Critical yield can also be expressed in millions of gallons per day (mgd) or acre-feet per year (ac-ft/yr), representing the volume of water that can be removed from a reservoir. The conversions between rate and volume are:

$$1 \text{ cfs} = 0.646317 \text{ mgd} = 723.964 \text{ ac-ft/yr}$$

The analysis in this critical yield report expresses critical yield in cfs.

METHODOLOGY

This section briefly describes how the USACE determined critical yield and crucial datasets that significantly affect the analysis results. A more detailed description of this process is provided in Appendix A - Critical Yield Methodology.

Unimpaired Flow Data Set

The unimpaired flow data set is historically average daily observed flows, adjusted for some of the human influence within the ACF river basin. Man-made changes in the river basin influence water flow characteristics and are reflected in measured flow records. Determining critical yield requires removing identifiable and quantifiable man-made changes such as municipal and industrial water withdrawals and returns, agricultural water use, and increased evaporation and runoff due to the construction of Federal surface water reservoirs, from the observed flow measurements.

These quantities are used to extrapolate diversions. The difference between water withdrawn and water returned is defined as a diversion. Diversions are a net volume or quantity assumed to be permanently lost from the water system.

The unimpaired flow dataset is not a perfectly replicated flow dataset representing conditions that would exist without the influence of human activities or a precise measure of natural flow conditions. This is because all human influences, such as land use changes, cannot be accounted for, and many flow set adjustments are estimates based upon assumptions, not direct measurements of the human influences.

The original unimpaired flow data set developed as part of the Alabama-Coosa-Tallapoosa and Apalachicola Chattahoochee Flint (ACT/ACF) River Basins Comprehensive Water Resources Study, ACT/ACF Comprehensive Water Resources Study, Surface Water Availability Volume I: Unimpaired Flow, July 8, 1997 included data at over 50 locations for the 1939 to 1993 period of record. This data set has recently been extended through 2011 and is available from the Corps. Because of the occurrence of negative flows in the daily values, the data has been smoothed using 3-, 5-, or 7-day averaging. This preserves the volume of the flow and eliminates most of the small negative flows in some of the daily flow data. The primary reason for the negative local unimpaired flows is related to estimating actual routing of flows. Routing travel times are limited to 24 hours in the daily ResSim model. Actual travel time may not coincide with the 24-hour increment through the entire flow range."

Droughts

Several drought periods have been identified from the historic record and from previous yield analyses (reference Appendix D – Prior Reports and References). Drought periods were identified in 1939-43; 1954-58; 1984-89; 1998-2003, and 2006-2008. These are shown below in Table 1. Each period is referenced in accordance to the decade or most severe year of occurrence. Critical yield was computed for each of the drought periods and the lowest value selected as the critical yield value for this report.

Table 1. Drought Periods

Drought Periods	Label
1939-1943	1940
1954-1958	1950
1984-1989	1980
1998-2003	2000
2006-2008	2007

Models

A computer simulation model is a computer program that replicates a real world system. The U.S. Army Corps of Engineers' Hydrologic Engineering Center's (HEC) Reservoir System Simulation (HEC-ResSim) is a computer program comprised of a graphical user interface (GUI) and a computational engine to simulate reservoir operations. HEC-ResSim was developed to aid engineers and planners performing water resources studies by representing the behavior of reservoirs and to help reservoir operators plan releases in real-time during day-to-day and emergency operations.

The updated HEC-ResSim model used in this study has a Yield Analysis subroutine which calculates the largest, continuous release that can be reliably supplied during the flow record. The subroutine works by adjusting an operation rule, which represents a reservoir management action. The subroutine performs a model simulation run through the period of record with a suggested release toward yield, then recomputes the release, and iterates the computed release until the largest release that can always be successfully made is found. This largest release if found when exactly 100% of available storage is utilized and nothing more.

The ResSim ACF yield model includes a net precipitation-evaporation rate for each reservoir that utilizes evaporation values developed for National Oceanic and Atmospheric Administration (NOAA) Technical Reports, monthly pan evaporation rates and National Weather Service

(NWS) reports of rainfall and flow rates. The net evaporation losses, evaporation minus precipitation, were computed in inches at the projects. The NOAA report was used because historic monthly evaporation data is not available at the projects. Historic monthly precipitation data was obtained from the NWS.

It is important to be aware that the most severe drought event at one reservoir may not be the most severe drought event at another reservoir in the same river system. For the purposes of computing critical yield on the ACF System, the lowest critical yield value (typically associated with the most severe drought event) at an upstream reservoir will be used to calculate a downstream reservoir's critical yield. This is because, on the ACF System, the amount of water exiting from an upstream reservoir influences the amount of water available in a downstream reservoir. This is germane to Methods A and B.

Critical yield at each reservoir is calculated for two conditions: without river and lake diversions and with river and lake diversions. Generally, the largest possible yield results from the no diversions condition (Method A) whereas the with diversions condition (Method B) results in the most critical, or lowest, yield. Method B also studies the effect of downstream controls on yield. Method C calculates the system critical yield at Walter F. George, investigating both the with and without diversions conditions.

The local unimpaired flow is used as the input time series for the reservoir model. The reservoir simulation model for this yield analysis uses a daily-time step for all computations. Model runs (simulations) are performed for each identified drought periods and capture the drawdown and refill of reservoir during the drought period.

Method A (Without Diversions)

Method A assumes that there are no withdrawals from or returns to the lake and there are no withdrawals from or returns to the river as it flows between projects. This condition results in the maximum yield possible from the Federal projects. Critical yield from an upstream reservoir is assumed to be permanently removed from the system and does not contribute to the inflow at downstream reservoirs.

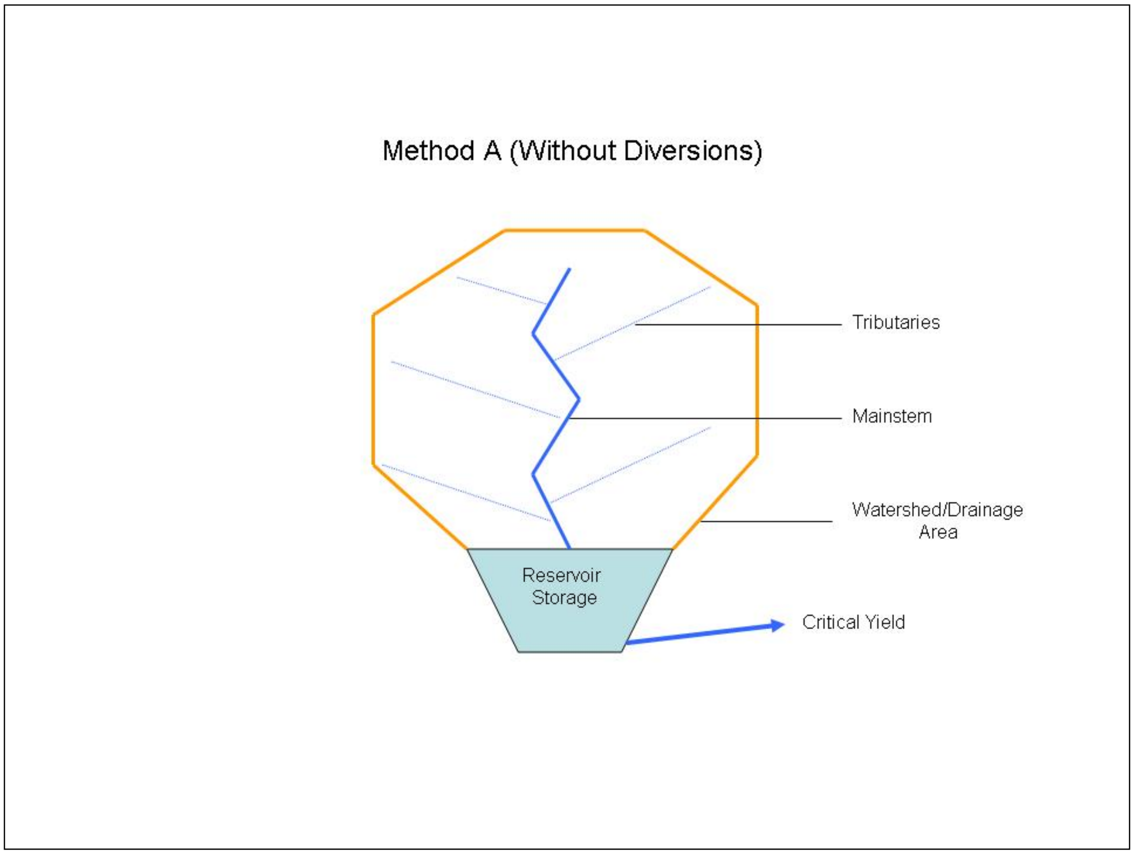


Figure 2. Critical Yield Method A (Without Diversions)

Method B (With Diversions)

Method B assumes net river withdrawals and returns are occurring; this method does not include withdrawals from the Corps reservoirs. Critical yield from an upstream reservoir is assumed to be permanently diverted from the system and does not contribute to the inflow at downstream reservoirs. This condition results in the most severe downstream impact. The results of Method B represent a conservative assessment of the critical yield available from Federal projects controlled by the Corps of Engineers. Method B used the most severe drought events documented during the hydrologic period of record and the year of maximum river withdrawals (2007 for the ACF) to make the calculations.

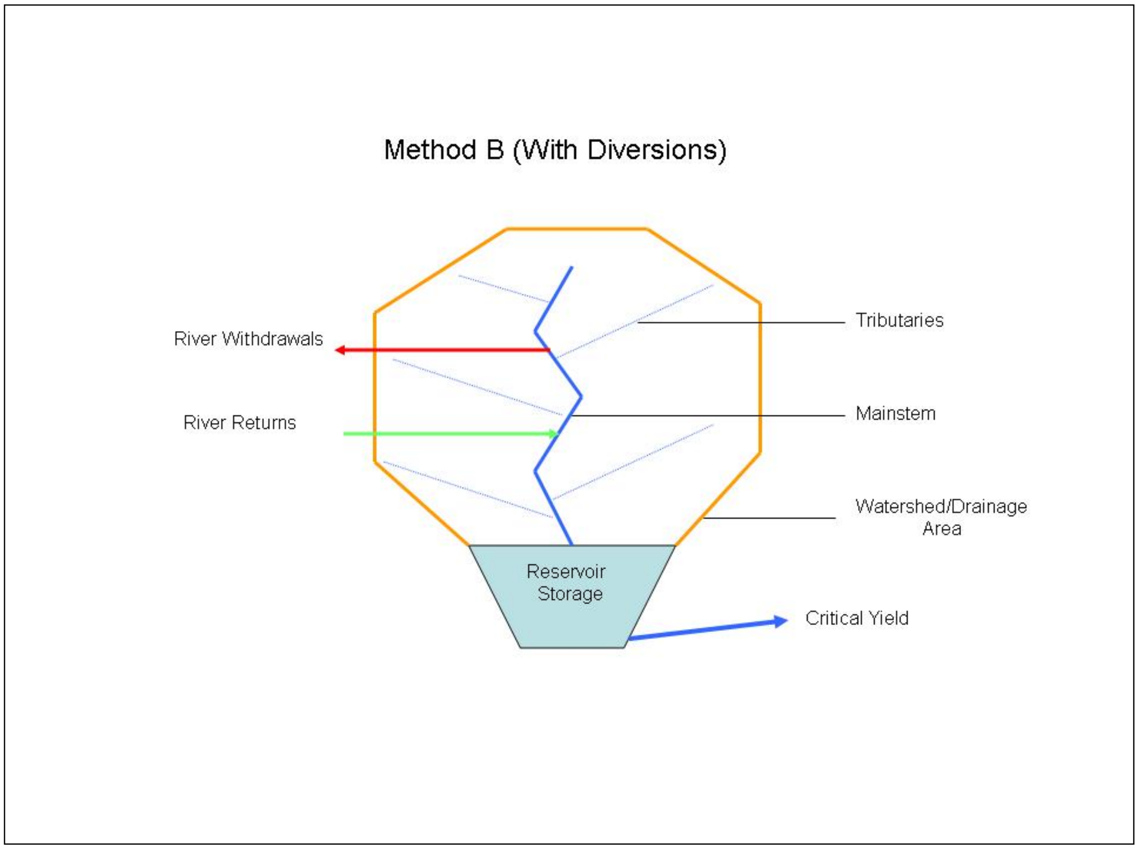


Figure 3. Critical Yield Method B (With Diversions)

The objective of Method B is to calculate reservoir yield given system diversions. The reservoirs can either operate by ignoring diversion demands or they can operate to meet diversion demands. In the first case, yield at Lake Lanier is found without regard to diversions below the reservoir and as a result, there may not be enough flow to meet diversion demands during the entire critical period. In the second case, a downstream control rule is included in the Lake Lanier operations to ensure enough instream flow to meet diversions. This second yield at Lake Lanier is the most critical so it is used to calculate yield for West Point and Walter F. George.

Method C (River System Yield)

Method C computes a system yield for diversion from the most downstream storage reservoir. It assumes upstream reservoirs operate in tandem to maximize the critical yield at the most downstream reservoir. Method C computes critical yield for the ACF River System with and without net river withdrawals. The with net river withdrawals condition results represent the Corps' yield. The without net river withdrawals condition results represent the system theoretical maximum yield. Method C calculates the theoretical critical yield that might be observed if the upstream projects were operated solely to maximize yield at Walter F. George Lake. However, in reality the results could not be achieved because the Corps must operate in a balanced manner to achieve all authorized project purposes.

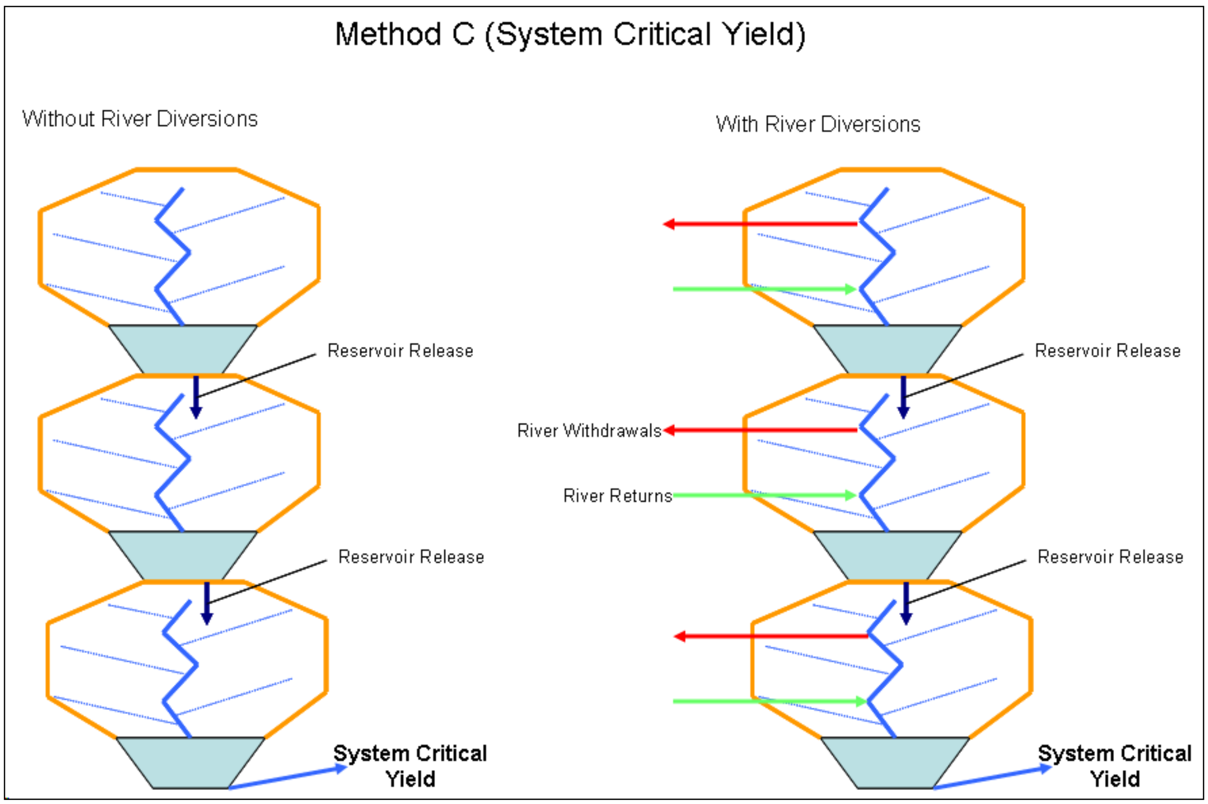


Figure 4. Critical Yield Method C (River System Yield)

Assumptions

Assumptions made for the critical yield analysis are listed below.

1. There is no attempt to address the probability that droughts more severe than those in the period of record may or may not occur.

2. The simulation model was operated primarily for critical yield. The only other operating purpose included was flood risk reduction. The critical yield represents the maximum flow that could be continuously provided to meet any, or all, demands (e.g., project purposes).

3. The upstream reservoir is the primary reservoir, and its yield is met (maximized) before proceeding downstream. This is because upstream users can consumptively divert water, precluding the availability of water yield to a downstream user. Maximizing the yield of the upstream reservoir is consistent with current state-issued water withdrawal permits and may not apply in other regions of the United States. This is significant since the ACF projects are operated in tandem.

4. Yield analysis is based on currently authorized conservation storage elevations.

5. Projects are full at the beginning of the drought period simulation. The pool level at the beginning of a drought simulation is important because it is a variable that directly affects the quantity or volume of water available as critical yield.

6. None of the critical yield from the existing reservoirs is returned to the system. Critical yield is permanently diverted from the system and assumed to be consumptively used. For example: Lake Lanier (Buford Dam) critical yield is not counted as inflow to West Point Lake. Inflows to West Point Lake are assumed to derive only from the West Point Lake drainage basin. This methodology determines the conservative individual project yield. The assumption is applicable to Methods A and B. The assumption is not applicable to Method C.

7. Existing area capacity curves as shown in the current water control manuals were used for all reservoirs but Lake Sidney Lanier. In 2011, a Sedimentation and Erosion Analysis for Lake Sidney Lanier was completed and new area capacity curves were recommended. This new curve was used in the critical yield analysis model. Figure E-1 compares the original and new area-capacity curves. Overall, Lake Sidney Lanier has consistently undergone light to no sedimentation in the main body of the Lake. Locations undergoing the greatest sedimentation are along the main stem of the Chattahoochee River, and at the heads of bays. Summary of storage gain/loss at key elevation listed below:
   Top of flood control 1085: 0.11% reduction
   Top of conservation 1071: 0.32% reduction
   Bottom of conservation 1035: 0.77% gain

No new curves were used at any other reservoir project because changes were not significant.

CRITICAL YIELD ANALYSES RESULTS

A summary of model results is presented below. A more detailed description of basin-specific methods, modeling and results is presented in the Appendix B.

Tables 2 and 3 list the critical yield of each existing federal reservoir on the ACF System and the critical drought period used in the calculations. In both tables, the proposed Glades and Bear Creek reservoirs act as run-of-river projects with no yield diverted out.

Table 2. Method A, ACF Project Yield (Without Diversions)

Project	Critical Yield (cfs)	Critical Drought
Lake Lanier (Buford Dam)	1459	1980
West Point Lake and Dam	809	2007
Walter F. George Reservoir and Lock & Dam	575	2007

The ACF River System diversions are municipal, industrial and agricultural withdrawals and returns from the Chattahoochee River and its tributaries located upstream of Lake Sidney Lanier, West Point Lake and Walter F. George Lake. Maximum river withdrawals occurred in 2007 and are reflected in the critical yield calculation for each drought period. Computation of Method A, ACF Project Yield (Without Diversions) did not include these withdrawals.

Table 3. Method B, ACF Project Critical Yield (With Diversions)

Project	Critical Yield (cfs)	Critical Drought	Critical Yield Change Attributable To Diversions
Buford Dam	1393	1980	-4.5%
West Point Dam	960	2007	+18%
Walter F. George Lock and Dam	477	2007	-17%

Comparing the critical yield results from the Method A (Without Diversions) and Method B (With Diversions) allows us to quantify the impacts of the river withdrawals. The 2007 river withdrawals had a measurable impact, decreasing yield at Buford and Walter F. George, but increasing critical yield at West Point. The yield at Buford is reduced due to operations that ensure flow for downstream river withdrawals. However, a large portion of these diversions are returned to the river upstream of West Point. As a result, the critical yield at West Point given upstream river diversions is 18% greater than the yield when there are no diversions.

The critical yield of the proposed Glades and Bear Creek reservoirs and their impact on the ACF system are listed in Table 4. Like the Federal Projects, yield is assumed to be diverted out of the system from Glades and Bear Creek.

Table 4. Method B, Diverted Yield from Glades and Bear Creek (With Diversions)

Project	Critical Yield (cfs)	Critical Drought	Critical Yield Change Attributable To Proposed Reservoirs
Glades	72	2007	-
Buford Dam	1329	1980	-4.6%
Bear Creek	16	2007	-
West Point Dam	956	2007	-0.34%
Walter F. George Lock and Dam	477	2007	-

Table 5 shows the yield at Buford assuming river withdrawals but not operating to completely fulfill those withdrawals. Buford yield values are greater than values in Tables 3 and 4 because Lake Lanier is not operating to provide flow for downstream diversions. This table also illustrates two proposed operations for Glades reservoir and their impact on Buford Yield: diverting Glades yield out of the system and diverting (releasing) Glades yield directly to Lake Lanier. The critical yield increases when diverting Glades yield back to Lake Lanier by 0.6% versus when Glades is a flow thru reservoir. There is a 4.4% reduction in Buford yield when diverting Glades yield out of the system rather than operating Glades as a flow thru reservoir.

Table 5. Method B, Buford Yield Analysis with River Diversions, No Downstream Control Operations

Project	Critical Yield (cfs)	Critical Drought	Critical Yield Change Attributable To Proposed Operation
Glades Flow Thru	1452	1980	-
Glades Diverting Out	1388	1980	-4.4%
Glades Releasing to Lake Lanier	1460	1980	+0.6%

Table 6 below lists the Method C (River System Yield) results of operating the three ACF reservoirs together as a system for yield at Walter F. George. When all reservoirs are operated for yield optimization at Walter F. George, the system yield obtained is greater than the sum of the individual reservoir yields.

Method C (River System Yield) was computed with and without river diversions. The 2007 river diversions reduce the critical yield at Walter F. George by 3.9 percent. This figure represents the percentage difference between 4,110 cfs (ACF System Without Divisions) and 3,948 cfs (ACF System With Diversions). Finally System Yield of 3,881 cfs computed with Glades and Bear Creek yield diverted out the system along with river diversions

Table 6. Method C, ACF (River System Yield)

Project	System Critical Yield (cfs)	Critical Drought
System (Without Diversions)	4110	2007
System (With Diversions)	3948	2007
System with Glades & Bear Creek (With Diversions)	3881	2007

SUMMARY

The results of Method B (With Diversions) (reference Table 3 - 5) represent a realistic assessment of the critical yield from the Federal projects controlled by the Corps. For the purpose of water supply storage contracts at Buford Dam (Lake Lanier), results from Table 5 are recommended. Current conditions do not include the proposed Glades Dam. The Table 5 “Glades Flow Thru’ alternative is representative of the Buford Dam yield for current conditions. Therefore Buford Dam current conditions yield is 1,452 cfs for the purpose of water supply storage contracts. This value includes the effect of year 2007 river withdrawals upstream of Lake Lanier.

Historical critical yield determinations are referenced in Appendix C - Prior Reports and References. The reader should be cautioned that there is not a direct correlation between the finding of historical critical yields and the findings of this Critical Yield Report. This is due to differences in the drought periods used in each set of analyses and methods employed to calculate the critical yield.

REFERENCES

USACE, July 8, 1997, “ACT/ACF Comprehensive Water Resources Study”

USACE, Mar 2010, “Federal Storage Reservoir Critical Yield Analysis ACT ACF”

USACE-HEC, Jan 2014, “Methods for Storage/Yield Analysis”

National Weather Service, June 1982, "Evaporation Atlas for the contiguous 48 United States", NOAA Technical Report NWS 33.

National Weather Service, December 1982, "Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States", NOAA Technical Report NWS 34.

ACRONYMS

Acres	ac
acre-feet	ac-ft
acre-feet per year	ac-ft/yr
Alabama-Coosa-Tallapoosa	ACT
Apalachicola-Chattahoochee-Flint	ACF
cubic feet per second	cfs
elevation	Elev
Federal Energy Regulatory Commission	FERC
graphical user interface	GUI
Hydrologic Engineer Center	HEC
Hydrologic Engineering Center's, Reservoir Simulation Model	HEC-ResSim
Kilowatt	kW
Million gallons per day	mgd
Mean Sea Level	msl
Megawatt	MW
National Geodetic Vertical Datum of 1929	NGVD 29
National Oceanic and Atmospheric Administration	NOAA
National Weather Service	NWS
Revised Interim Operating Plan	RIOP
U.S. Army Corps of Engineers	Corps
United States Geological Survey	USGS

Appendix A

Critical Yield Methodology

Appendix A - Critical Yield Methodology

1 INTRODUCTION

The methodology describing how the Corps determined critical yield and the crucial datasets that significantly affect analyses results is detailed below.

1.1 RIVER DIVERSIONS

The difference between water withdrawn from a river and water returned to the river is defined as a diversion. Diversions are a net volume or quantity assumed to be permanently lost from the river.

1.1.1 Unimpaired Flow Data Set

The unimpaired flow data set is average daily historically observed flows, adjusted for some of the human influence within the river basins. Man-made changes in the river basins influence water flow characteristics and are reflected in measured flow records. Determining critical yield requires removing identifiable and quantifiable man-made changes such as municipal and industrial water withdrawals and returns, agricultural water use, and increased evaporation and runoff due to the presence of surface water reservoirs, from the observed flow measurements.

The daily unimpaired flow data set is used as the input flow series for all yield model simulations and represents the Corps' best estimate of a pre-development flow series. By making these flow adjustments for man-made activities, any combination of water demands input to the ResSim model and modeled over the entire flow record (1939 – 2011), produces a consistent basis for comparing yield results. Yield simulations are computed for with no water diversion and with current water diversion scenarios using current river diversions to compute yield accounts for existing conditions.

The unimpaired flow dataset is not an exact replication of a flow dataset representing conditions that would exist without the influence of human activities or a precise measure of natural flow conditions. This is because all human influences, such as land use changes, cannot be accounted for, and many flow set adjustments are estimates based upon assumptions, not direct measurements of the human influences.

The original unimpaired flow data set developed as part of the Alabama-Coosa-Tallapoosa and Apalachicola Chattahoochee Flint (ACT/ACF) River Basins Comprehensive Water Resources Study, ACT/ACF Comprehensive Water Resources Study, Surface Water Availability Volume I: Unimpaired Flow, July 8, 1997. The Comprehensive Study was conducted by the States of Alabama, Florida and Georgia and the Corps pursuant to a Memorandum of Understanding. One purpose of the study was to identify available water resources and water demands in the ACT and ACF Basins, and recommend a coordination mechanism for the equitable allocation of water resources between the States. Several technical modeling and assessment tools were developed to support this process, including the unimpaired flow dataset and the HEC-5 hydrological model.

The process accumulated data at over 50 locations for the 1939 to 1993 period of record. Because of the occurrence of negative flows in the daily values, the data has been smoothed using 3-, 5-, or 7-day averaging. This preserves the volume of the flow and eliminates most of the small negative flows in some of the daily flow data. The primary reason for the negative local unimpaired flows is related to estimating actual routing of flows. Routing travel times are limited to 24 hours in the daily ResSim model. Actual travel time may not coincide with the 24-hour increment through the entire flow range.

The Mobile District modeling team updates the unimpaired flow data sets every 1 - 3 years employing water use data provided by the States of Alabama, Florida and Georgia. The unimpaired flow datasets are reviewed by the states before finalizing. All supporting data and the final results of the analyses are provided to the states. This data set has recently been extended through 2011 and is available from the Corps of Engineers.

1.2 DROUGHT PERIOD UTILIZED IN CRITICAL YIELD

Several drought periods have been identified from the historic record and from previous yield analyses (reference Appendix D - References and Prior Reports). Drought periods were identified in 1939-43; 1954-58; 1984-89; 1998-2003, and 2006-2008. These are shown below in Table A-1 and described in more detail at Appendix D - Drought Descriptions.

Each period is referenced in accordance to the decade or most severe year of occurrence. Critical yield was computed for each of the drought periods and the lowest value selected as the critical yield value for this report.

Table A-1. Drought Periods

Drought Periods	Label
1939-1943	1940
1954-1958	1950
1984-1989	1980
1998-2003	2000
2006-2008	2007

The most recent drought and recovery period extends beyond 2008. Lake Lanier reached a historic low elevation of 1050.79 feet NGVD on December 28, 2007, and nearly again on December 8, 2008, when the pool reached elevation 1051 feet NGVD. A return to almost normal rainfall and conservative management allowed the reservoir to refill 20 feet over the next 10 months.

Lake Lanier recovery was marked by reaching full pool elevation of 1071 feet NGVD on October 14, 2009. Figure A-1 shows the most recent critical period for Lake Lanier and includes the drawdown and refill period through 2009.

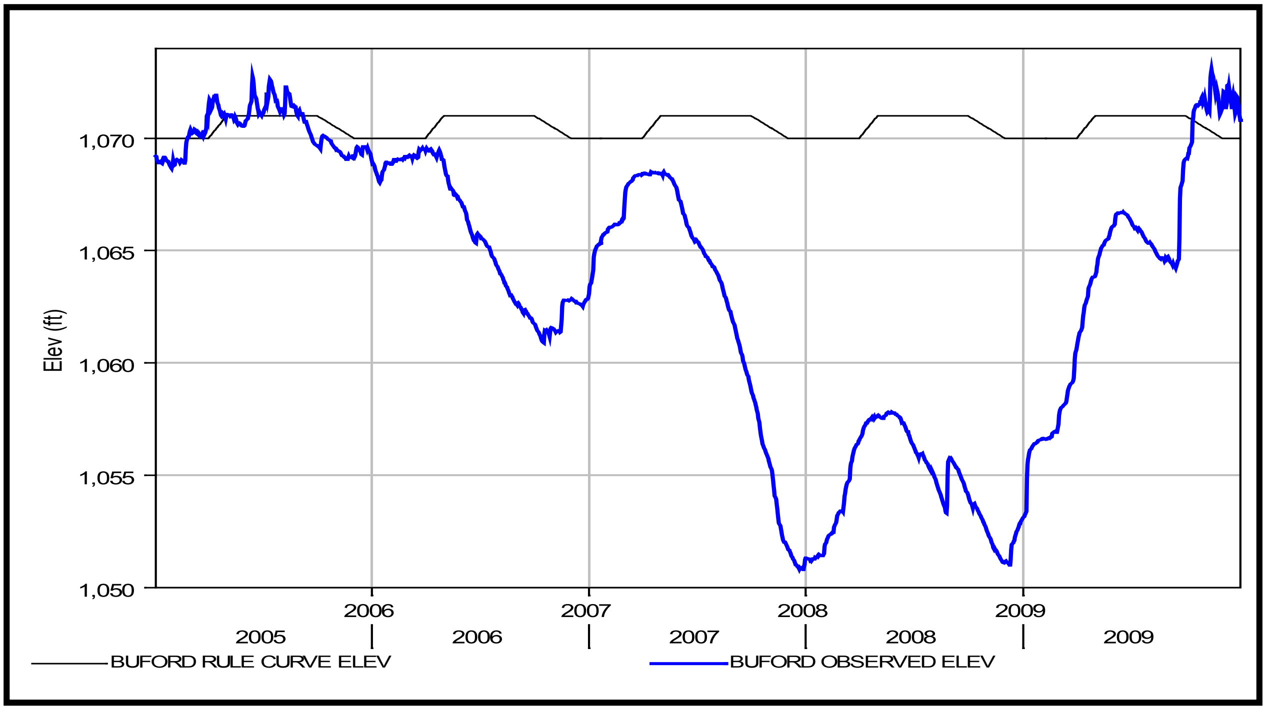


Figure A-1. Lake Lanier Pool Elevation 2005-2009

1.3 MODELS

A computer simulation model is a computer program that simulates a simplified model of a real system. The U.S. Army Corps of Engineers' Hydrologic Engineering Center's (HEC) Reservoir System Simulation (HEC-ResSim) is a computer program comprised of a graphical user interface (GUI) and a computational engine to simulate reservoir operations. HEC-ResSim was developed to aid engineers and planners performing water resources studies by representing the behavior of reservoirs and to help reservoir operators plan releases in real-time during day-to-day and emergency operations.

The HEC-ResSim Yield Analysis calculates the release for a single minimum release operation rule that drains the reservoir's pool to empty once in the period of record. This figure can also be described as the largest release that can be supplied reliably throughout the record. This "reliable release" is also known as the critical yield and in previous documents has been referred as to prime flow. The process involves computing a simulation run with an estimate of the largest release, and recomputing iteratively with successive estimates until the correct release is found.

The user enters the maximum number of iterations that will be run and two tolerance values. The Storage Test Tolerance value shares the same units as the reservoir storage and is the value the reservoir must decrease in order to be considered empty. It is used as the tolerance for all the zone storage values listed in the reservoir table. The Rule Test Tolerance value shares the same units as the minimum release rule and is used in the calculations as a test for violations of the minimum release rule.

The ResSim ACF yield model includes a net precipitation-evaporation rate for each reservoir that utilizes evaporation values developed for National Oceanic and Atmospheric Administration (NOAA) Technical Reports, monthly pan evaporation rates and National Weather Service (NWS) reports of rainfall and flow rates. The net evaporation losses, evaporation minus precipitation, were computed in inches at the projects. The NOAA report was used because historic monthly evaporation data is not available at the projects. Historic monthly precipitation data was obtained from the NWS.

The local unimpaired flow is used as the input time series for the reservoir model. The reservoir simulation model for this yield analysis uses a daily-time step for all computations. Model runs (simulations) are performed for each identified drought periods and capture the drawdown and refill of reservoir during the drought period.

1.4 METHODS EMPLOYED IN CRITICAL YIELD ANALYSIS

There are several ways of computing critical yield. Sequential analysis is currently the most accepted method. This method uses the conservation of mass principles to account for the water in the reservoir inflows and releases. The fundamental equation is:

$$I - O = \Delta S$$

Where:

I = Total inflow during the time period, in volume units

O = Total outflow during the time period, in volume units

ΔS = Change in storage during the time period, in volume units

Sequential routing uses an iterative form of the above equation:

$$S_t = S_{t-1} + I_t - O_t$$

Where:

S_t = Storage at the end of time t, volume units

S_{t-1} = Storage at the end of time t-1, volume units

I_t = Average inflow during time step Δ, in volume units

O_t = Average outflow during time step Δ, in volume units

The HEC-ResSim computer application uses sequential analysis and the sequential routing method with the application's Yield Analysis routine to maximize yield from a specified amount of storage.

It is important to be aware that the most severe drought event at one reservoir may not be the most severe drought event at another reservoir in the same river system. For the purposes of computing critical yield on the ACF System, the lowest critical yield value (typically associated with the most severe drought event) at an upstream reservoir will be used to calculate a downstream reservoir's critical yield. This is because, on the ACF System, the amount of water exiting an upstream reservoir influences the amount of water available in a downstream reservoir. This is germane to Methods A and B described below.

1.4.1 Method A (Without Diversions)

Method A assumes that there are no withdrawals from or returns to the lake or the river as it flows between projects. This condition results in the maximum yield possible from the Federal projects. Critical yield from an upstream reservoir is assumed to be permanently removed from the system and does not contribute to the inflow at downstream reservoirs.

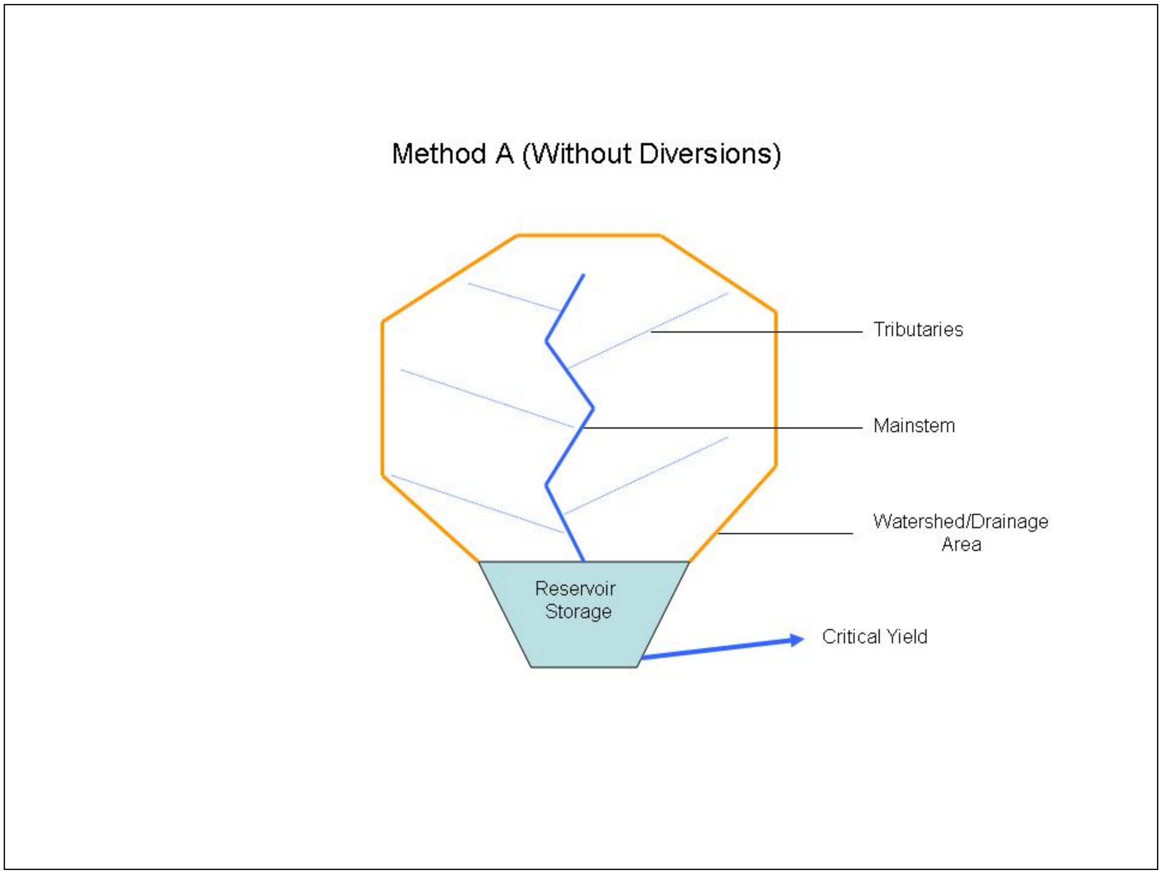


Figure A-2. Critical Yield Method A (Without Diversions)

1.4.2 Method B (With Diversions)

Method B assumes net river withdrawals and returns are occurring; this method does not include withdrawals from the Corps reservoirs. Critical yield from an upstream reservoir is assumed to be permanently diverted from the system and does not contribute to the inflow at downstream reservoirs. This condition results in the most severe downstream impact. The results of Method B represent a realistic assessment of the critical yield available from Federal projects controlled by the Corps. Method B used the most severe drought events documented during the hydrologic period of record and the year of maximum river withdrawals (2007 for the ACF) to make the calculations.

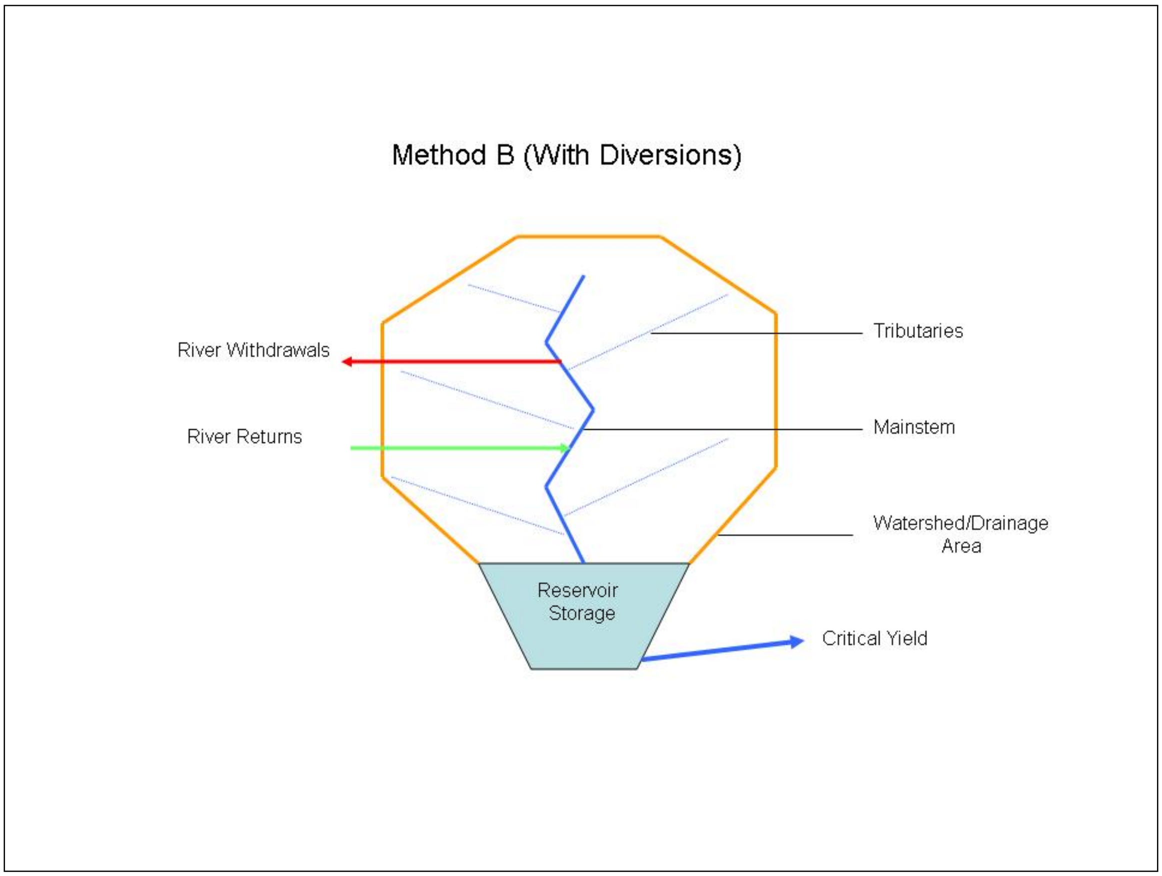


Figure A-3. Critical Yield Method B (With Diversions)

The objective of Method B is to calculate reservoir yield given system diversions. The reservoirs can either operate by ignoring diversion demands or they can operate to meet diversion demands. In the first case, yield at Lake Lanier is found without regard to diversions below the reservoir and as a result, there may not be enough flow to meet diversion demands during the entire critical period. In the second case, a downstream control rule is included in the Lake Lanier operations to ensure enough instream flow to meet diversions. This second yield at Lake Lanier is the most critical so it is used to calculate yield for West Point and Walter F. George.

1.4.3 Method C (River System Yield)

Method C computes a system yield for diversion from the most downstream storage reservoir. It assumes upstream reservoirs operate in tandem to maximize the critical yield at the most downstream reservoir. Method C computes critical yield for the ACF River System with and without net river withdrawals. The with net river withdrawals condition results represent the Corps' yield. The without net river withdrawals condition results represent the system theoretical maximum yield.

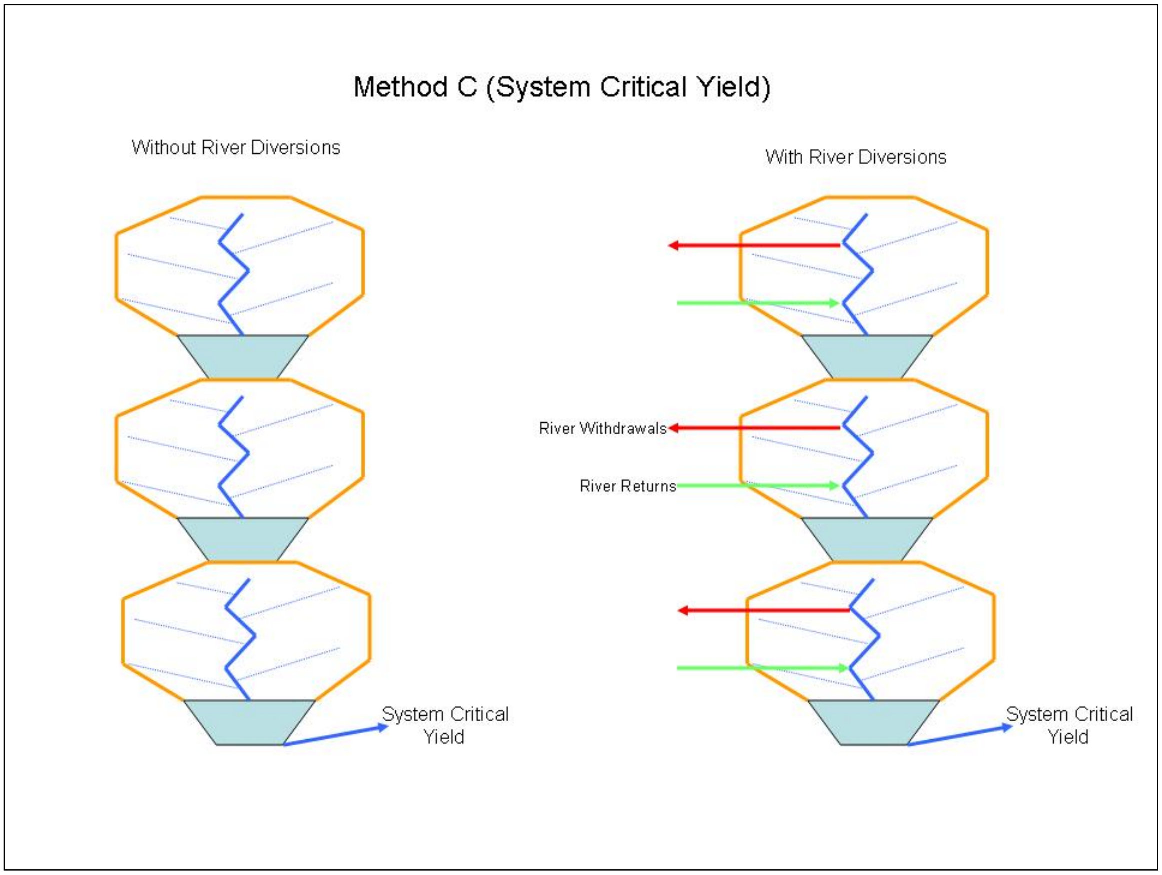


Figure A-4. Critical Yield Method C (System Critical Yield)

1.4.4 Seasonal Storage

The amount of conservation storage (storage resulting from operating at the conservation pool) is seasonal at federal projects because of the seasonal drawdown to support flood reduction operations. Table A-2 lists the elevation difference in the guide curve and reduction in conservation storage for the federal projects.

Table A-2. Seasonal Conservation Storage Reduction

Project	Elevation Difference (feet)	Storage Difference (ac-ft)	Percent Reduction In Conservation Storage
Lanier (Buford)	1 = 1071 – 1070	38,100	4%
West Point	7 = 635 – 628	162,232	53%
Walter F. George	2 = 190 – 188	87,300	36%

For West Point and Walter F. George, the yield of these projects is highly dependent on the beginning of the critical dry period. In other words, it matters whether the critical period begins during the winter, summer, or transition level of the guide curve. Although all three projects have a high probability of refill to summer pool from a low winter level, extreme rare events will prevent the project from refilling. Consequently, if the critical period begins before the reservoir reaches full summer level the critical yield will be lower than when compared to starting at full summer level. For the determination of critical yields, the yield simulation begins approximately one year before the drought period begins. The analyses assume about one year of normal flows prior to the beginning of the drought period. Drawdown could start whenever flows were low enough for the lake to fall below a target level, be it winter, summer or transition. For the efficiency of computations, separate drought periods were run, always considering the prior year average flows and assuming the highest possible elevation on the guide curve as the target level.

Appendix B

Apalachicola-Chattahoochee-Flint (ACF) Basin Detailed Analysis

Appendix B - Apalachicola-Chattahoochee-Flint Basin Detailed Analysis

1 ACF BASIN

1.1 DESCRIPTION OF BASIN

Streams of the Apalachicola-Chattahoochee-Flint Rivers (ACF) Basin begin as small Appalachian springs in the Blue Ridge Mountains of North Georgia. The spring waters flow for over 400 miles until the Chattahoochee River combines with the Flint River, forming the Apalachicola River at the Georgia, Florida border. From the confluence the Apalachicola flows an additional 108 miles to the Gulf of Mexico. The ACF Basin extends about 385 miles from northeast Georgia to the Gulf of Mexico. The total drainage area of the ACF Basin is approximately 20,500 square miles.

The largest metropolitan area in the basin is Atlanta, Georgia, located in the northern section. Progressing downstream are the Cities of Columbus, Georgia and Phenix City, Alabama. Albany, Georgia is located in the eastern portion of the basin. At the Gulf of Mexico is the City of Apalachicola, Florida. Features are shown in Figure C-1.

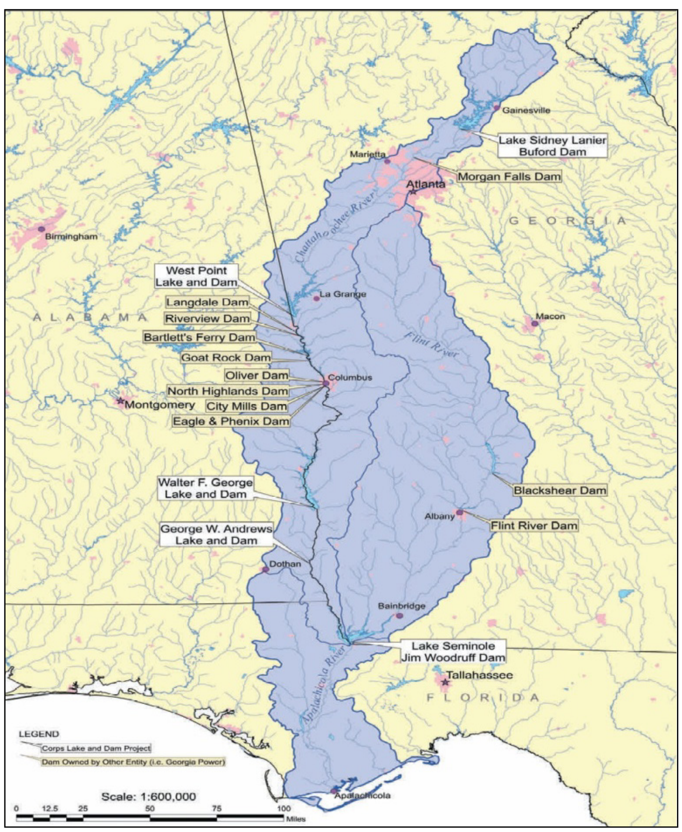


Figure B-1. ACF Basin

1.1.1 Physical Description

Chattahoochee Tributaries. The headwaters of the ACF System originate with spring-fed streams feeding Chattahoochee tributaries in northern Georgia mountains. The mountain slopes are steep, with rapid runoff during rainstorms. One of the most upstream tributaries is the Chestatee River that flows into Lake Lanier. In contrast to the mainstream of the Chattahoochee River, many tributaries remain free flowing. Flows in forested tributary basins and those in Metropolitan Atlanta retain similar runoff patterns. They have higher sustained flows during winter months, and relatively quick responses to storm events throughout the year. However, sharper peaks in the hydrographs of urban streams such as Peachtree Creek reflect the influence of impervious land cover in the urbanized parts of the basin.

Chattahoochee River. The Chattahoochee River has a drainage area of 8,800 square miles. The headwaters rise as cold-water mountain streams in the Blue Ridge Province at altitudes above 3,000 feet. From its beginning the river flows 434 miles to its confluence with the Flint River. The Chattahoochee River derives its name from Creek Indian words meaning painted rock. This river is one of the most heavily used water resources in Georgia.

Through most of its length, flows in the Chattahoochee River are controlled by hydroelectric plants releasing water for production of hydropower. These hydroelectric plants use peaking operations to augment power supply during peak demand periods. Daily fluctuations below some reservoirs can be dramatic. Fluctuations are usually more pronounced during low flow periods when hydropower releases often cause daily fluctuations of several feet.

The Chattahoochee River includes five federal projects operated by the Corps of Engineers: Buford Dam (Lake Lanier), West Point Dam and Lake, Walter F. George Lock & Dam and Reservoir, George W. Andrews Lock and Dam, and Jim Woodruff Lock and Dam (Lake Seminole). Of these, Lake Sidney Lanier (Buford Dam), West Point Lake, and Walter F. George Reservoir (Walter F. George Dam) provide most of the water storage available to regulate flows in the basin. Lake Sidney Lanier alone provides 63 percent of the conservation storage for the basin, although only five percent of the ACF River Basin drains into the lake. In addition, West Point Lake and Lake Walter F. George provide 18 and 14 percent, respectively, of the basin's conservation storage. Lake Seminole has some storage to regulate weekly flows, and the Georgia Power lake at Morgan Falls Dam provides daily regulation.

Georgia Power Company operates seven projects on the Chattahoochee River. One is north of Atlanta, Georgia and the remaining six are located along the Fall Line near Columbus, Georgia. These projects are Morgan Falls Dam, Langdale Dam, Riverview Dam, Bartletts Ferry Dam, Goat Rock Dam, Oliver Dam and North Highlands Dam. None of these Georgia Power projects have any significant storage and, therefore, do not contribute to the yield of the system.

In addition two small run-of-river dams at Columbus, Georgia located downstream of North Highlands Dam have recently been removed for ecosystem restoration and recreation purposes. They were the City Mills Dam owned by City Mills, and Eagle and Phenix Mills Dam owned by Uptown Columbus Inc. Habersham Mill Dam is located in the headwaters above Buford Dam.

Flint River. The Flint River Basin (8,468 square miles) includes Crisp County Dam and Lake (also known as Warwick or Blackshear Lake), and Albany Dam (also known as the Flint River Dam) that impounds Lake Worth. The river begins as a spring or groundwater seep underneath the runways of Hartsfield-Jackson International Airport. The flow is channeled off the airport by large drainage pipes. From the airport it meanders 350 miles in a basin that is approximately 212 miles in length. It has 220 miles of unimpeded flow, making it one of only 40 rivers in the U.S. with open flows of 200 miles or more of near natural stream. The Flint River remains relatively undeveloped, and for much of its length the river is free flowing.

Apalachicola River. The Flint River empties into Lake Seminole near Bainbridge, Georgia, where it joins the Chattahoochee River at the Florida state line near the Jim Woodruff Dam to form the Apalachicola River. The Apalachicola River Basin (3,235 square miles) includes Jim Woodruff Lock and Dam (Lake Seminole), which is operated by the Corps of Engineers. The river lies completely within the Coastal Plain and is 108 miles in length. The Apalachicola River then flows south across northwest Florida from the Georgia border to Apalachicola Bay in Florida.

1.1.2 Climate

The chief factors that control the climate of the ACF Basin are its geographical position in the southern end of the Temperate Zone, its proximity to the Gulf of Mexico and South Atlantic Ocean, and its range in altitude from almost sea level at the southern end to over 3,000 feet in the Blue Ridge Mountains to the north. The proximity of the warm South Atlantic and the semitropical Gulf of Mexico ensures a warm, moist climate. Extreme temperatures range from near 110 degrees in the summer to values near zero in the winter. Severe cold weather rarely lasts longer than a few days. The summers, while warm, are usually not oppressive. In the southern end of the basin the average maximum January temperature is 60 degrees and the average minimum January temperature is 37 degrees.

The maximum average July temperature is 91.5 degrees; in the southern end of the basin the corresponding minimum values value is 70.4 degrees. The frost-free season varies in length from about 200 days in the northern valleys to about 250 days in the southern part of the basin. Precipitation is mostly in the form of rain, but some snow falls in the mountainous northern region on an average of twice a year.

1.1.3 Precipitation

The entire ACF Watershed lies in a region which ordinarily receives an abundance of precipitation. The watershed receives a large amount of rainfall and it is well-distributed throughout the year. Winter and spring are the wettest periods and early fall, the driest. Light snow is not unusual in the northern part of the watershed, but constitutes only a very small fraction of the annual precipitation and has little effect on runoff. Intense flood producing storms occur mostly in the winter and spring. They are usually of the frontal-type, formed by the meeting of warm moist air masses from the Gulf of Mexico colliding with the cold, drier masses from the northern regions, and may cause heavy precipitation over large areas. The storms that occur in summer or early fall are usually of the thunderstorm type with high intensities over smaller areas. The occurrence of tropical disturbances and hurricanes can produce high intensities of rainfall over large areas.

1.1.4 Storms and Floods

Major flood-producing storms over the ACF Watershed are usually of the frontal type, occurring in the winter and spring and lasting from 2 to 4 days, with their effect on the basin depending on their magnitude and orientation. The axes of the frontal-type storms generally cut across the long, narrow basin. Frequently a flood in the lower reaches is not accompanied by a flood in the upper reaches and vice versa. Occasionally, a summer storm of the hurricane type, such as the storms of July 1916 and July 1994, will cause major floods over practically the entire basin. However, summer storms are usually of the thunderstorm type with high intensities over small areas producing serious local floods. With normal runoff conditions, from 5 to 6 inches of intense rainfall are required to produce widespread flooding, but on many of the minor tributaries 3 to 4 inches are sufficient to produce local floods.

Principal Storms. During most years there are one or more flooding events within the ACF Basin. However, on occasion there are significant storms that produce widespread flooding or unusually high river stages.

1.1.5 Runoff Characteristics

Within the ACF Basin rainfall occurs throughout the year but is less abundant during the August through November time frame. The amount of this rainfall that actually contributes to streamflow varies much more than the rainfall. Several factors such as plant growth and the seasonal rainfall patterns contribute to the volume of runoff.

Tables B-1, B-2, and B-3 present the average monthly runoff for the basin. These tables divide the basin at Atlanta, and Columbus, Georgia and Blountstown, Florida to show the different percentages of runoff verses rainfall for the various sections. The mountainous areas exhibit flashier runoff characteristics and somewhat higher percentages of runoff. Figures B-2, B-3, and B-4 present the same information in graphical form.

The percent runoff due to rainfall is computed by dividing the Average Monthly rainfall (inch) by Average Monthly Discharge (inch) incrementally for each location. The Monthly Discharge is converted from cfs to depth of water over incremental drainage area then by dividing the total volume of water through the month by the incremental drainage area. NOAA’s National Climatic Data Center average monthly rainfall by climatic zone used to represent the three selected city locations. Cities and corresponding climatic zones are as listed; Atlanta, used GA Division 2, Columbus used GA Division 4 and AL Division 5, Blountstown use GA Division 7 and FL Division 1. Monthly Unimpaired Flows used as source for Monthly Discharge. Daily unimpaired flows for period of record 1939 through 2011 converted to monthly for 3 locations; Atlanta, Columbus and Blountstown. The monthly incremental discharge at Columbus computed by subtraction the monthly Atlanta flow and Blountstown monthly incremental flow computed by subtracting out the Columbus monthly discharge. Drainage area used to convert cfs to inches, Atlanta 1,590 square miles, Columbus 3,080 square miles and Blountstown 12,930 square miles.

Table B-1. Basin Rainfall and Runoff above Atlanta

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT ATLANTA, GEORGIA												
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) AT ATLANTA	3,422	3,842	4,337	3,715	2,881	2,318	2,063	1,861	1,645	1,632	1,968	2,640
AVG RUNOFF IN INCHES	2.48	2.54	3.14	2.61	2.09	1.63	1.50	1.35	1.15	1.18	1.38	1.91
AVG RAINFALL IN INCHES	5.36	5.15	6.11	4.46	4.27	4.25	5.05	4.21	3.98	3.42	4.23	4.86
PERCENT OF RAINFALL AS RUNOFF	46%	49%	52%	58%	49%	38%	30%	32%	29%	35%	33%	39%

Rainfall Source: NOAA National Climatic Data Center, 1939-2011

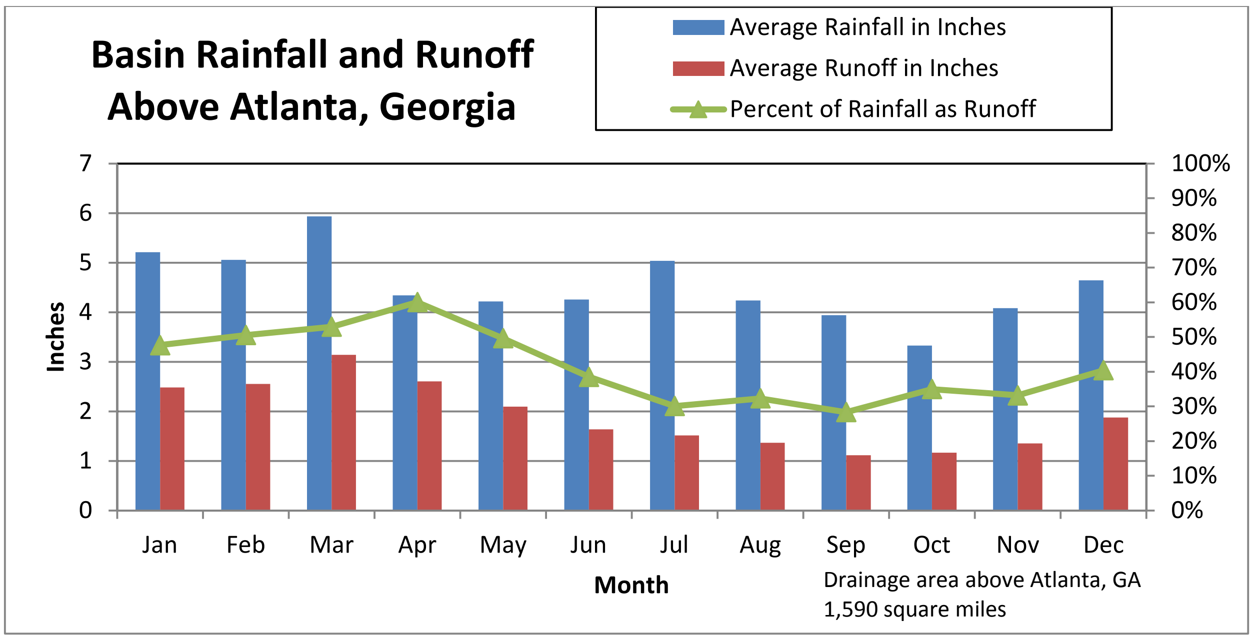


Figure B-2. Basin Rainfall and Runoff above Atlanta, Georgia (1939-2011)

Table B-2. Basin Rainfall and Runoff between Columbus and Atlanta

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT COLUMBUS, GEORGIA												
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) BETWEEN ATLANTA AND COLUMBUS	5,503	6,676	7,912	6,418	4,228	3,054	3,034	2,376	2,034	2,088	3,041	4,204
AVG RUNOFF IN INCHES	2.06	2.28	2.96	2.33	1.58	1.11	1.14	0.89	0.74	0.78	1.10	1.57
AVG RAINFALL IN INCHES	4.85	4.96	6.12	4.44	3.86	4.19	5.27	3.99	3.72	2.70	3.83	4.70
PERCENT OF RAINFALL AS RUNOFF	42%	46%	48%	52%	41%	26%	22%	22%	20%	29%	29%	33%

Rainfall Source: NOAA National Climatic Data Center, 1939-2011

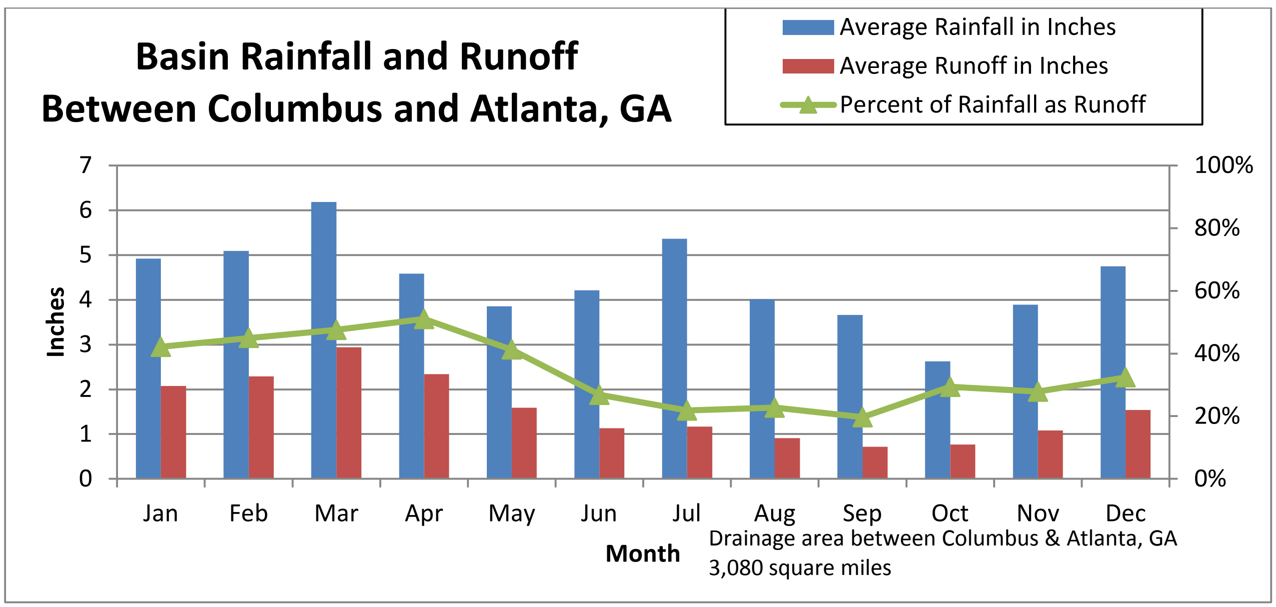


Figure B-3. Basin Rainfall and Runoff between Columbus and Atlanta, Georgia (1939-2011)

Table B-3. Basin Rainfall and Runoff between Blountstown, FL and Columbus, GA

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT BLOUNTSTOWN, GEORGIA												
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) BETWEEN COLUMBUS AND BLOUNTSTOWN	19,221	23,652	28,557	24,863	15,985	12,311	12,978	10,985	8,830	8,760	8,755	14,119
AVG RUNOFF IN INCHES	1.71	1.92	2.55	2.15	1.43	1.06	1.16	0.98	0.76	0.78	0.76	1.26
AVG RAINFALL IN INCHES	4.59	4.50	5.53	4.05	3.70	5.24	6.64	5.60	4.75	2.74	3.35	4.22
PERCENT OF RAINFALL AS RUNOFF	37%	43%	46%	53%	39%	20%	17%	17%	16%	29%	23%	30%

Rainfall Source: NOAA National Climatic Data Center, 1939-2008

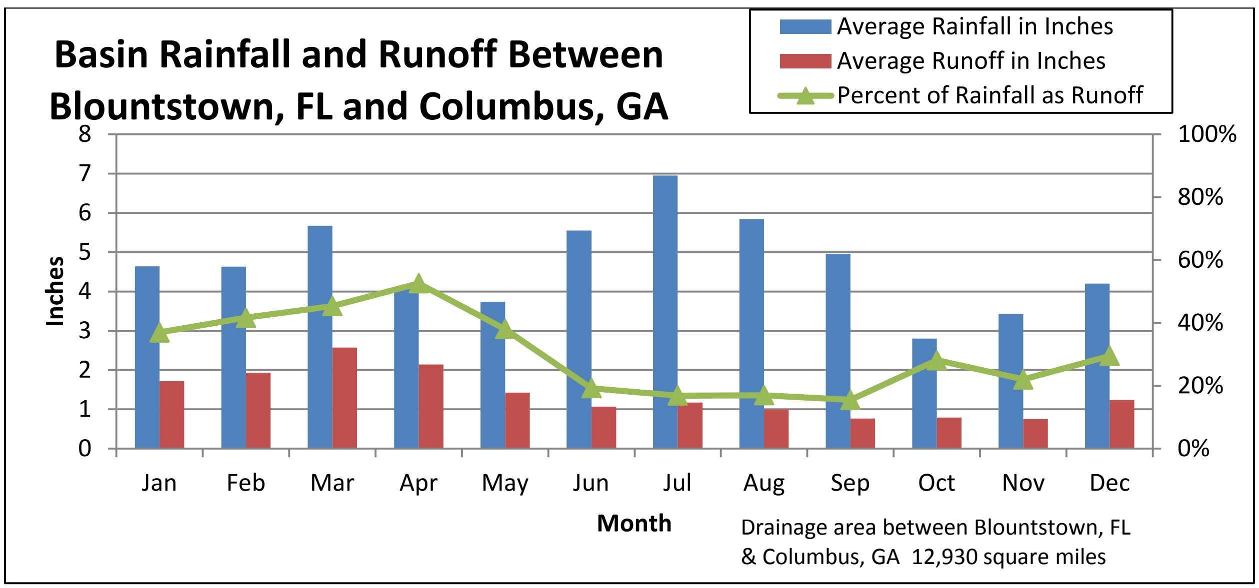


Figure B-4. Basin Rainfall and Runoff between Blountstown, FL and Columbus, GA (1939-2011)

1.2 RESERVOIRS

1.2.1 Reservoir Storage

There are five (5) federally owned reservoir projects within the ACF Basin. These are Buford Dam (Lake Lanier), West Point Dam, Walter F. George Lock & Dam and Reservoir, George W. Andrews Lock and Dam, and Jim Woodruff Lock and Dam (Lake Seminole). These projects were built and are operated by the Corps of Engineers, Mobile District Office. As mentioned above, Lake Sidney Lanier alone provides 63 percent of conservation storage, although only five percent of the ACF River Basin drains into the lake. In addition, West Point Lake and Walter F. George Reservoir provide 18 and 14 percent, respectively, of the basin's conservation storage. The conservation storages by reservoir are shown in Table B-4 and graphically in Figure B-5 below.

Table B-4. ACF Basin Conservation Storage by Project

Project	Conservation Storage (ac-ft)	Percentage
Lake Lanier	1,074,600	63%
West Point	306,127	18%
Walter F. George	244,400	14%
George Andrews	8,200	1%
Lake Seminole	66,847	4%
Total	**1,700,174**	

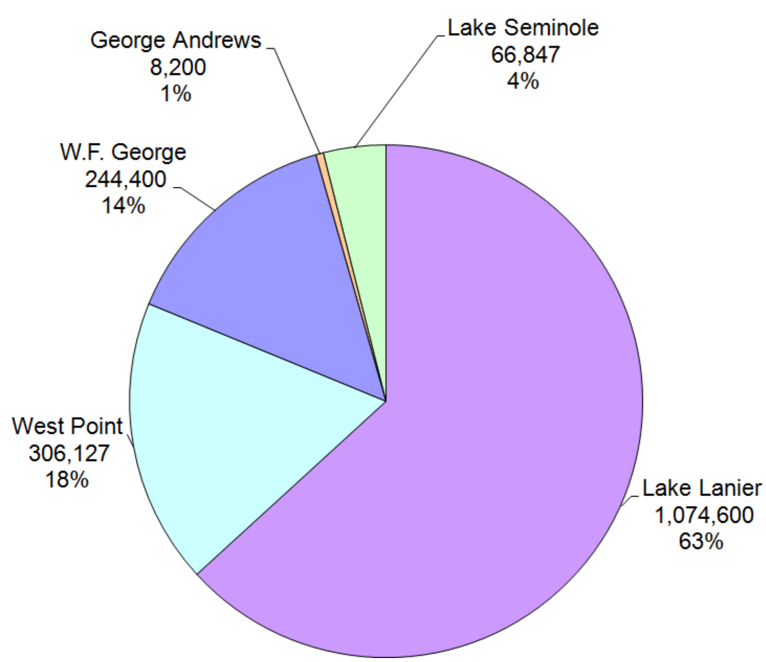


Figure B-5. ACF Basin Federal Reservoir Conservation Storage Percent by Acre-Feet

1.2.2 Reservoirs Selected for Yield

The only federal projects with significant storage are Buford Dam (Lake Lanier), West Point Dam and Lake, and Walter F. George Lock and Dam (and Reservoir). These three projects in the basin account for 95 percent of the total basin conservation storage. Therefore, yield analyses were done only on these three projects. These analyses are presented separately.

1.3 BUFORD DAM (LAKE SIDNEY LANIER)

Buford Dam (Lake Lanier) is the uppermost project in the basin. The site is located 50 miles northeast of central Atlanta, Georgia on the Chattahoochee River, 348.3 river miles above the Apalachicola River or 456 river miles from the Gulf Coast. Above Buford Dam, the Chattahoochee River Basin has a length of 52 miles, and an average width of 20 miles, with extreme widths ranging from a maximum of 36 miles in the headwater area to a minimum of 12 miles in the vicinity of the dam site. The drainage area above the dam is 1,040 square miles. The project was completed in June 1957.

Buford Dam is a multiple-purpose project with major project purposes including flood control, navigation, hydroelectric power, recreation, fish and wildlife development and water quality. An aerial photo of the main dam is shown on Figure B-6.

Figure B-6. Buford Dam

1.3.1 Drainage area

The Chattahoochee River and its upstream tributaries originate in the Blue Ridge Mountains of northern Georgia, near the western tip of South Carolina. The upper reaches of the basin streams are characterized by the steep slopes of mountain streams. The upper Chattahoochee River (157 square miles) is joined by the Soque River (166 square miles) about 60 miles northeast of Atlanta, Georgia and 11 miles upstream of the limits of the pool at elevation 1071 feet. The Chestatee River, a major tributary, formerly flowed into the Chattahoochee River above the dam site but now forms an arm of Lake Sidney Lanier, as shown on Figure B-7. Presently the Chattahoochee and Chestatee Rivers have drainage areas of 565 and 304 square miles and there is a drainage area of 115 square miles into the lake below their junction. The Chattahoochee and Chestatee Rivers comprise 84 percent of the dam site drainage; the reservoir pool comprises five percent and the remaining area is composed of minor streams which drain directly into the pool. The drainage area is shown on the following Figure B-7.

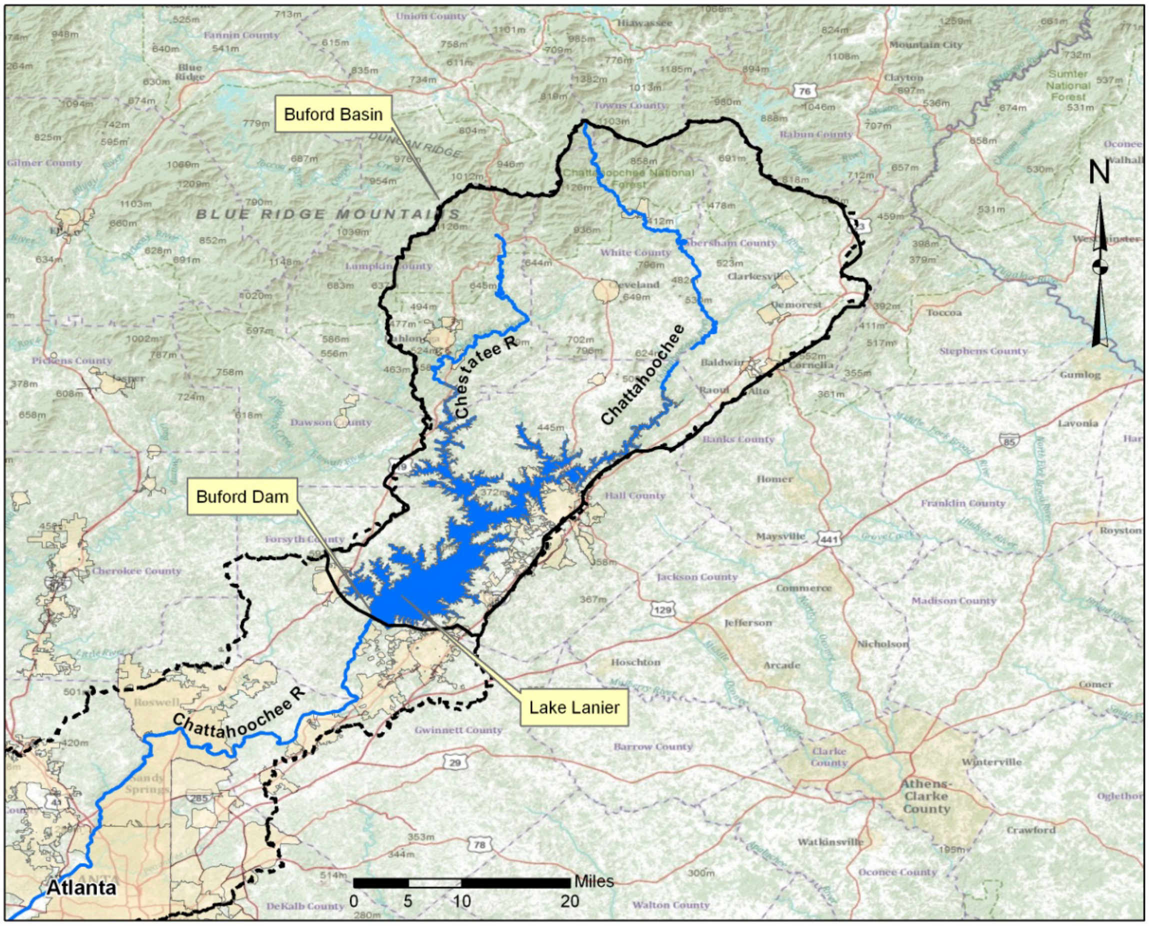


Figure B-7. Buford Basin Map

The drainage area is shown in relation to the rest of the basin in the following Figure B-8. This figure shows the local or incremental area between projects. These areas will be used in the yield computations to determine local flows at the downstream project, rather than the whole basin above the project. For the Buford project, however, there is no upstream project, so the total area above Buford is used in the yield computations.

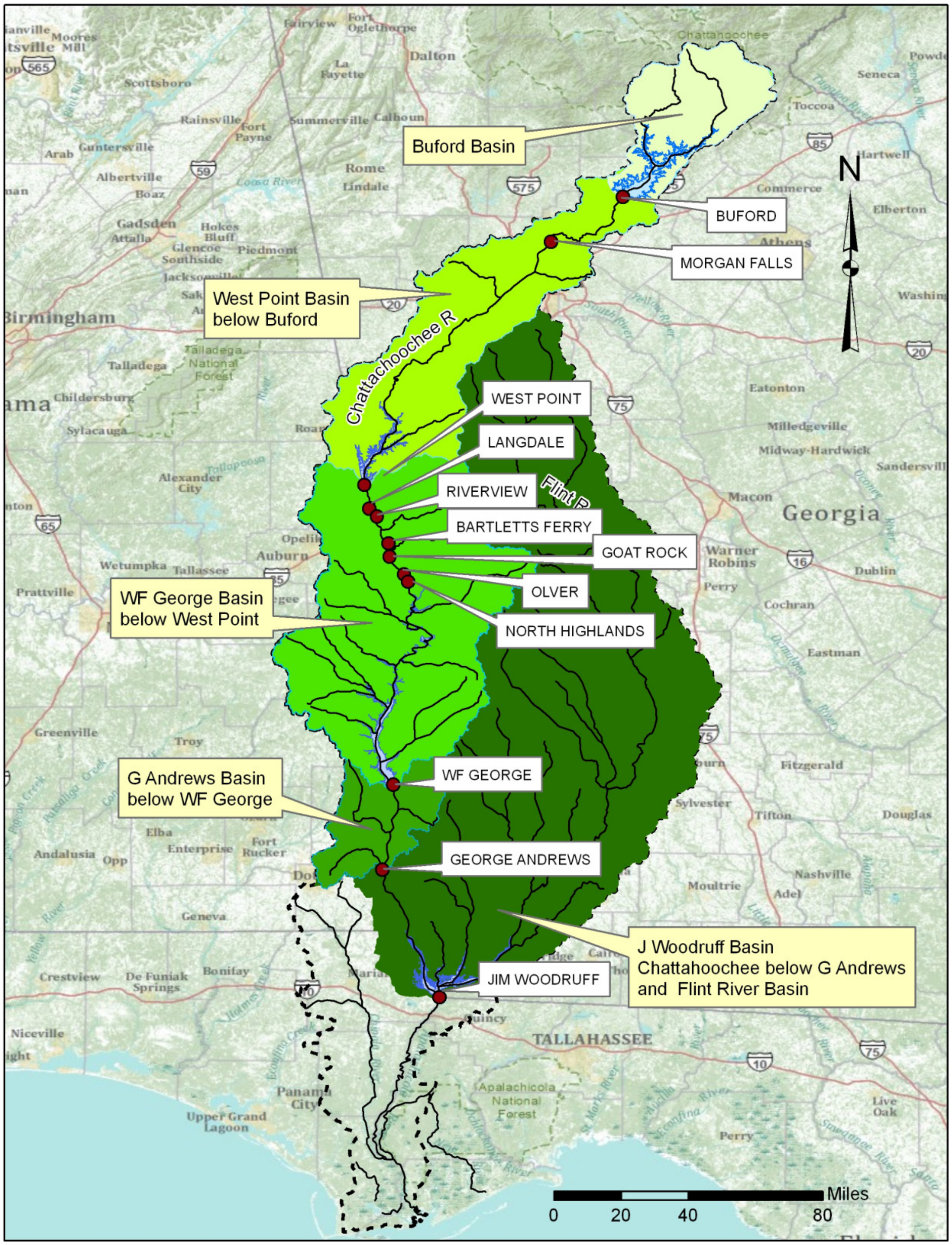


Figure B-8. Incremental Drainage Basin Map for Federal Projects on the ACF

1.3.2 Features

The project consists of an earth dam supplemented by earth saddle dikes and an unpaved chute spillway, an 86,000 kW power plant and appurtenances, and a reservoir extending about 44 miles up the Chattahoochee River and about 19 miles up the Chestatee River at full conservation pool. The main dam and reservoir are described below.

1.3.2.1 Dam

The main dam, 1,630 feet long and 192 feet high at maximum section, is an earth-fill structure with a rock section on the upstream side. The crest at elevation 1106 feet is 40 feet wide.

1.3.2.2 Reservoir

The reservoir has a total storage capacity of 2,551,100 acre-feet at full flood control pool, elevation 1085 feet, and covers an area of 48,176 acres. At full conservation pool, elevation 1071 feet, the reservoir covers 38,425 acres and has a total storage capacity of 1,948,900 acre-feet; at minimum conservation pool, elevation 1035 feet, the area covered is 22,293 acres with storage capacity of 874,300 acre-feet. Area-capacity curves are shown on Figure B-9 and Table B-5. Conservation storage varies seasonally from 1,035,500 acre-feet to 1,074,600 acre-feet between a minimum elevation of 1035 feet and a top of conservation pool elevation varying from 1070 to 1071 feet. However, another purpose of the project is flood control, and storage of 640,300 acre-feet between elevation 1070 and elevation 1085 feet has been reserved for the detention storage of flood water. The yield analysis will be based on the conservation storage as described above.

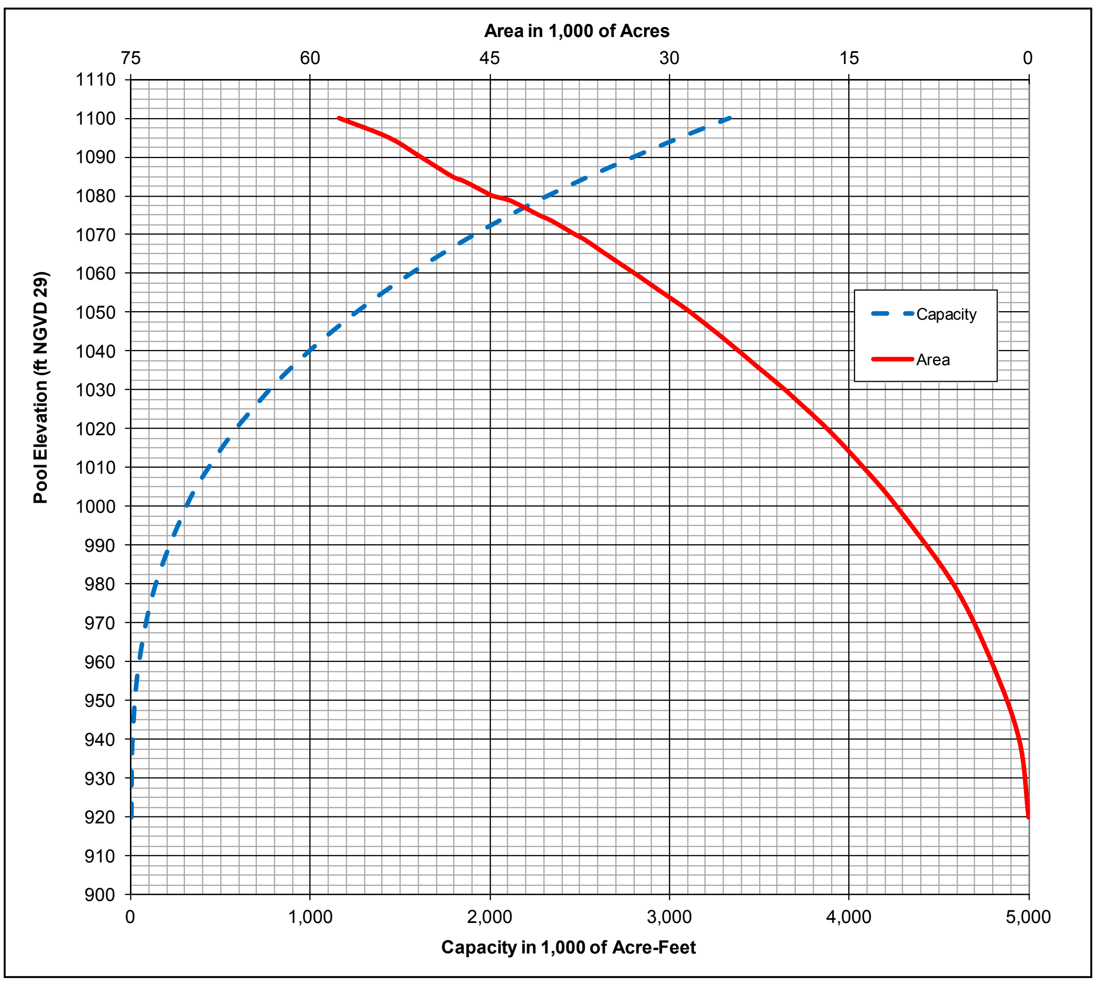


Figure B-9. Buford Area – Capacity Curves (circa 2011)

Table B-5. Buford Reservoir Area and Capacity Data (circa 2011)

Pool Elev	Total Area	Total Storage
(ft NGVD 29)	(ac)	(ac-ft)
920	42	100
940	831	6,300
960	3134	43,100
980	6316	135,500
1000	11052	305,900
1010	13805	429,800
1020	16842	582,500
1030	20352	767,800
1031	20728	788,400
1032	21119	809,200
1033	21509	830,500
1034	21897	852,200
* 1035	22293	874,300
1036	22681	896,700
1037	23068	919,600
1038	23449	942,800
1039	23833	966,400
1040	24223	990,400
1041	24617	1,014,800
1042	25006	1,039,600
1043	25399	1,064,800
1044	25795	1,090,300
1045	26200	1,116,300
1046	26613	1,142,700
1047	27019	1,169,500
1048	27433	1,196,700
1049	27850	1,224,300
1050	28262	1,252,300
1051	28698	1,280,800
1052	29149	1,309,700
1053	29616	1,339,000
1054	30094	1,368,800
1055	30569	1,399,100
1056	31043	1,429,900
1057	31509	1,461,200
1058	31969	1,492,900
1059	32436	1,525,100
1060	32914	1,557,700
1061	33397	1,590,800
1062	33883	1,624,500
1063	34370	1,658,600
1064	34853	1,693,100
1065	35332	1,728,200
1066	35806	1,763,800
1067	36276	1,799,800
1068	36753	1,836,300
1069	37257	1,873,300
** 1070	37871	1,910,800
*** 1071	38425	1,948,900
1072	38974	1,987,600
1073	39533	2,026,800
1074	40148	2,066,600
1075	40896	2,107,000
1076	41514	2,148,200
1077	42138	2,190,000
1078	42785	2,232,400
1079	43536	2,275,500
1080	44794	2,319,300
1081	45440	2,364,400
1082	46057	2,410,100
1083	46678	2,456,500
1084	47352	2,503,400
1085	48176	2,551,100
1090	50783	2,798,300
1095	53459	3,058,500
1100	56,500	3,332,500
1110	62,900	3,908,600

* Bottom of Conservation Pool
** Top of Winter Conservation Pool
*** Top of Summer Conservation Pool

1.3.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 1070 to 1071 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 1071 from 1 May through 1 October, then decrease to 1070 feet by 1 December, then hold 1070 feet unti1 15 April, and then increase to 1071 feet by 1 May. Figure B-10 presents the guide curve to be used. A constant top-of conservation pool level at elevation 1070 feet had been used until 1976. In February 1976 the extra storage was approved by the Division Engineer. A plot of the top of the conservation pool is shown on the following Figure B-10.

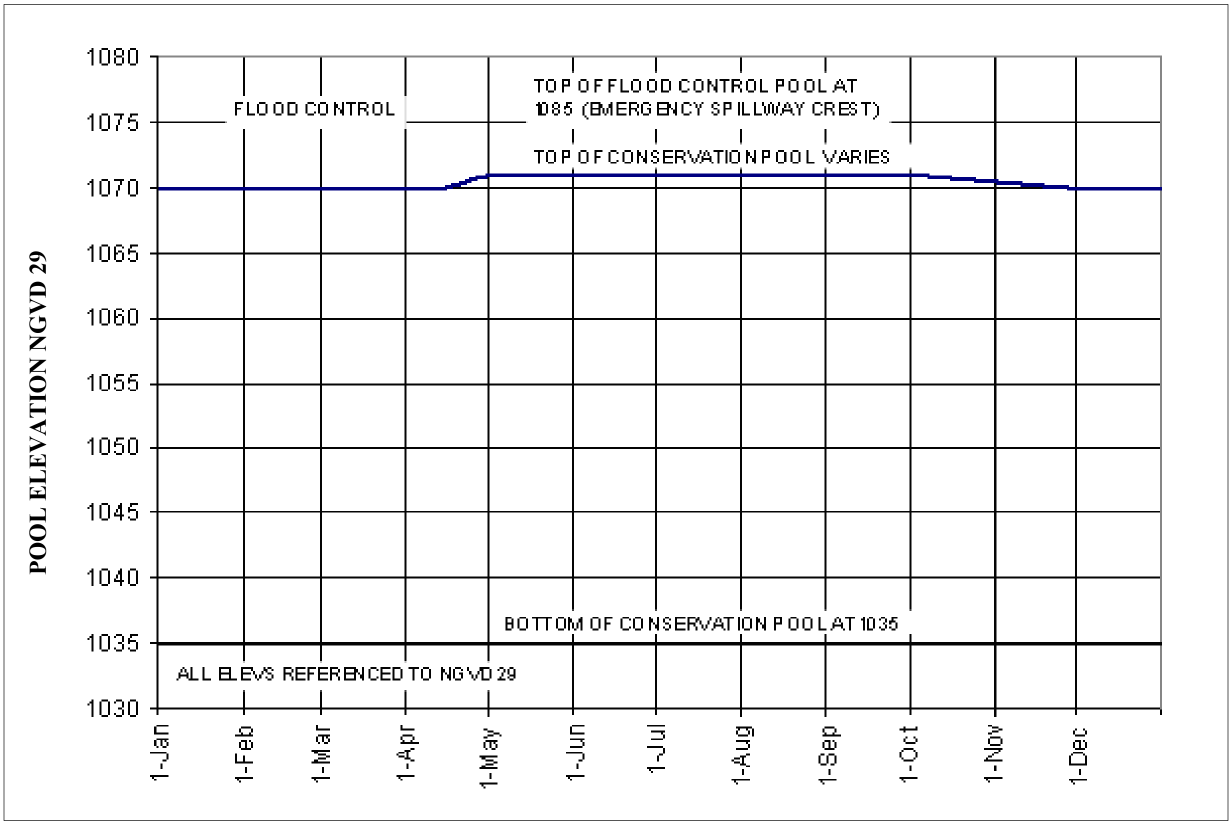


Figure B-10. Top and Bottom of Buford Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 1071 (or 1070 depending on the time of year) to 1035.

1.3.4 Regulation Plan

Normally the Buford project is operated as a peaking plant for the production of hydroelectric power and maintains a continuous flow of approximately 650 cfs during off-peak periods. Releases from Buford Dam are re-regulated by Georgia Power Company's Morgan Falls Dam (Bull Sluice Lake) to insure the City of Atlanta has sufficient flow for water supply and wastewater assimilation. In addition, increased flows during low flow periods are utilized by Corps of Engineers projects at West Point, Walter F. George, and Jim Woodruff for hydropower, to aid navigation and meet the flow requirements of the Jim Woodruff Revised Interim Operating Plan (RIOP).

1.3.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in Jan 1958, just as the pool was filling through 2011 are available. The data are presented in the following Figure B-11.

1.3.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2011 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2011 is shown in Figure B-12. Daily flows for critical drought periods are plotted in more detail in Figures B-13 – B-17.

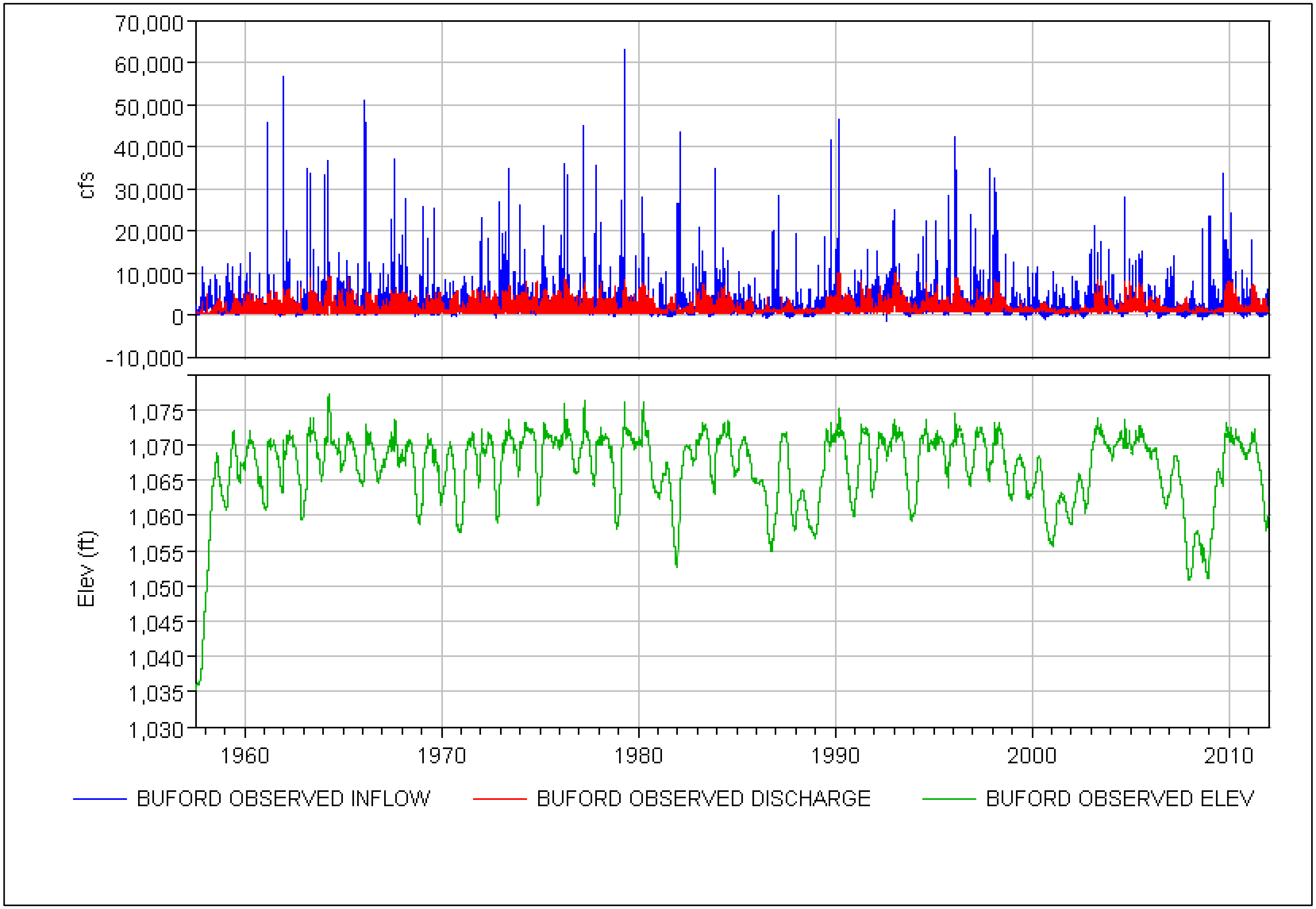


Figure B-11. Buford Inflow-Outflow-Pool Elevation (Jul 1957-Dec 2011)

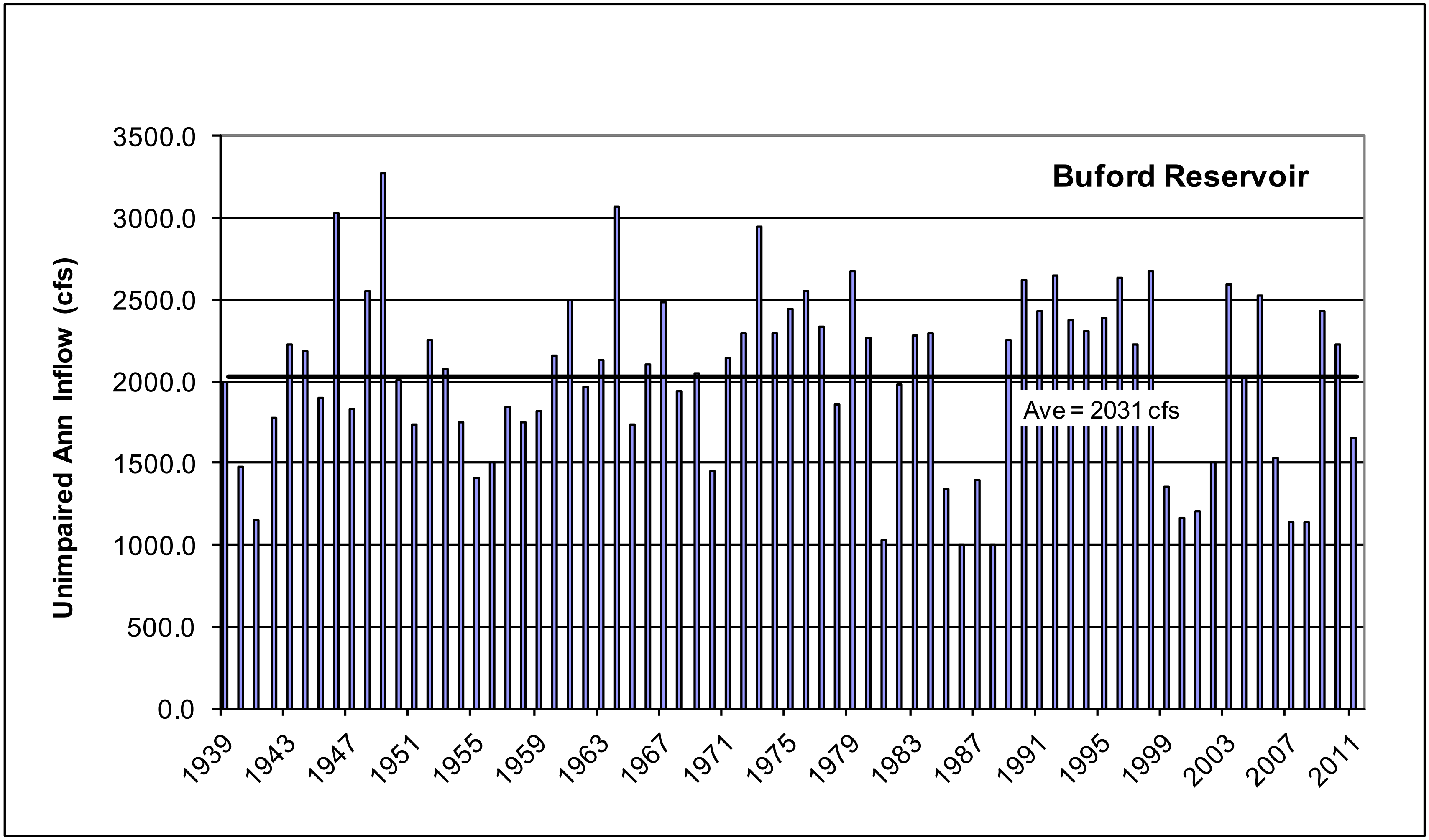


Figure B-12. Buford Unimpaired Annual Inflow Jan 1939 to Dec 2011

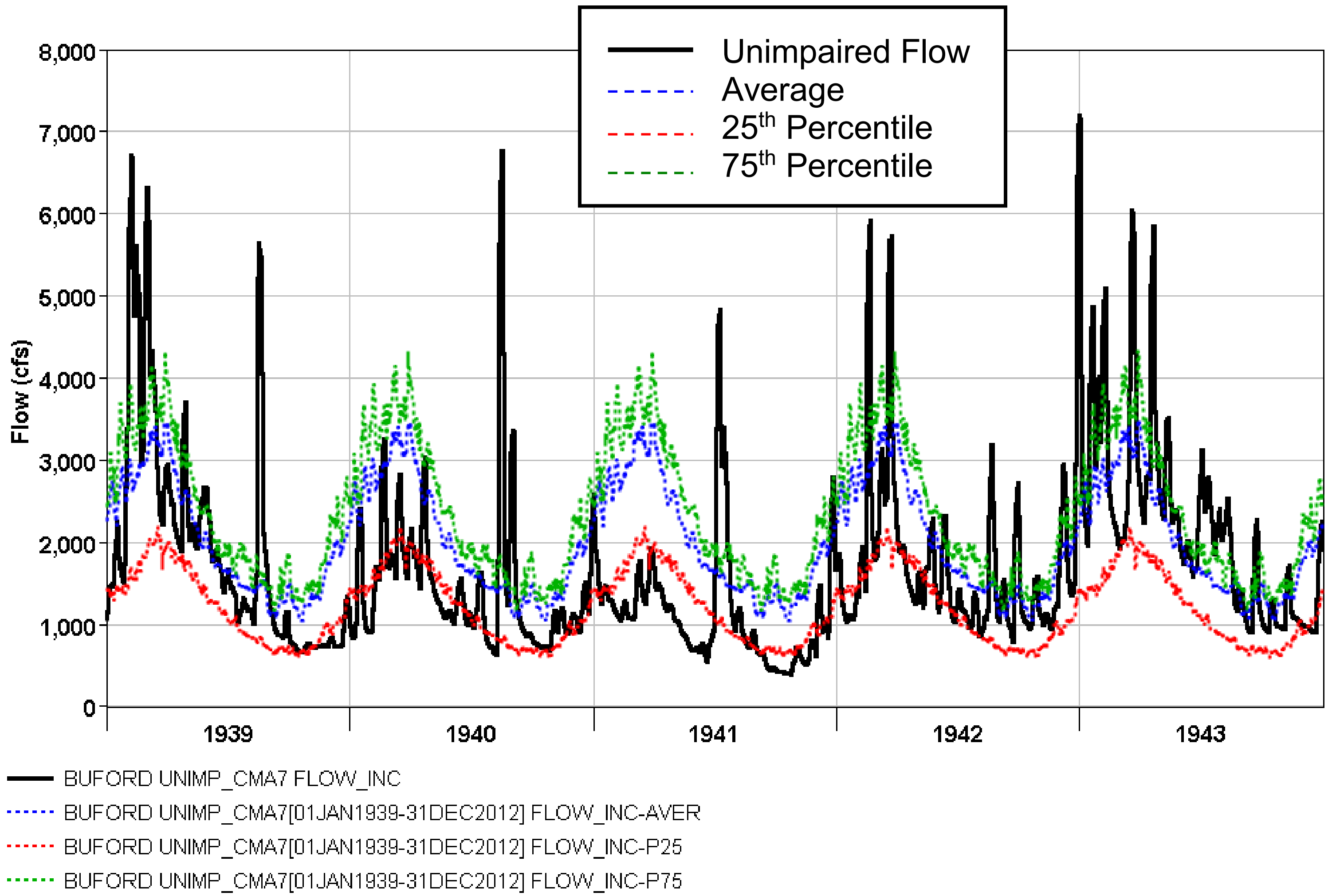


Figure B-13. Buford Unimpaired Inflow – 1940's Drought

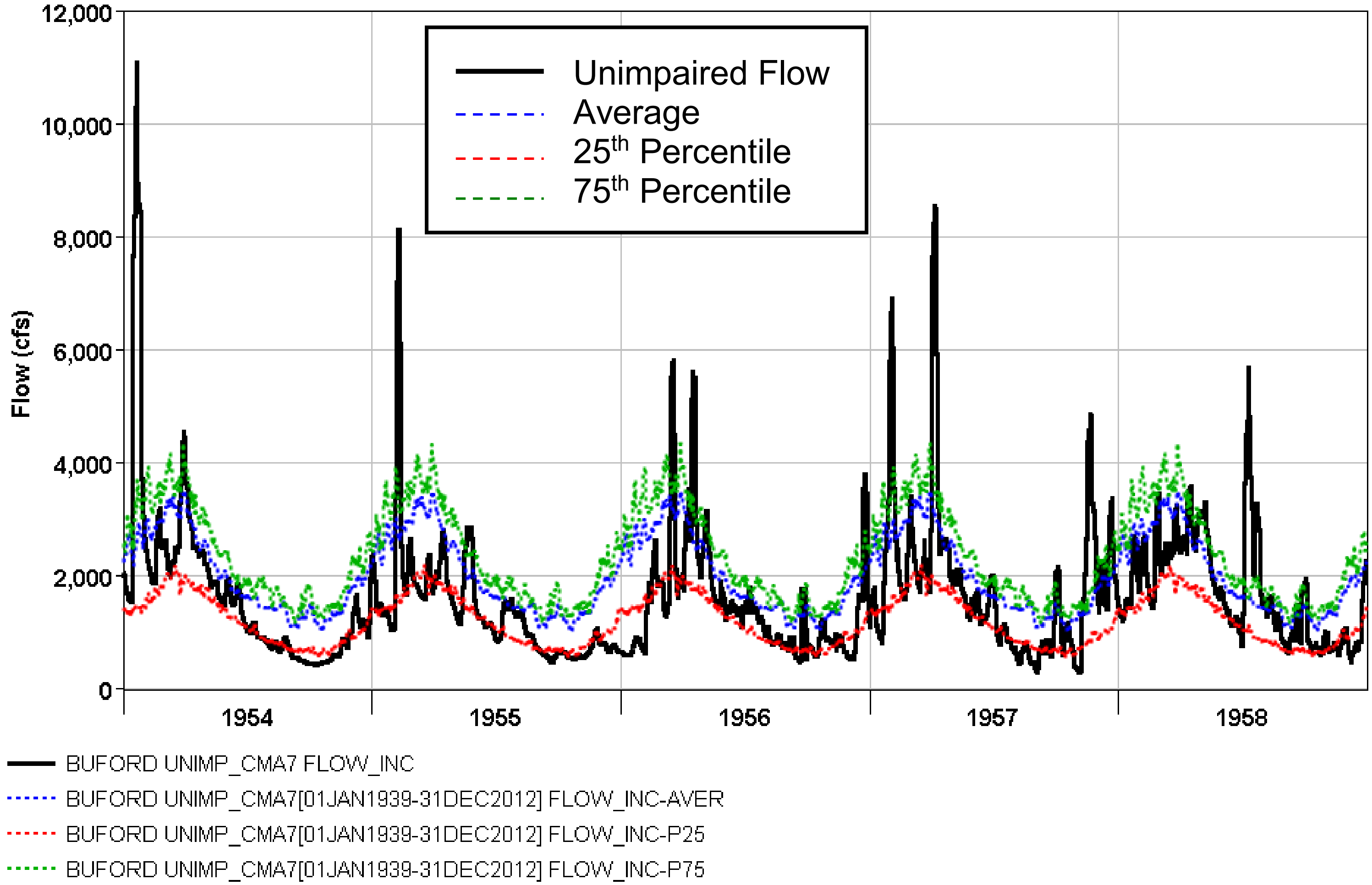


Figure B-14. Buford Unimpaired Inflow – 1950's Drought

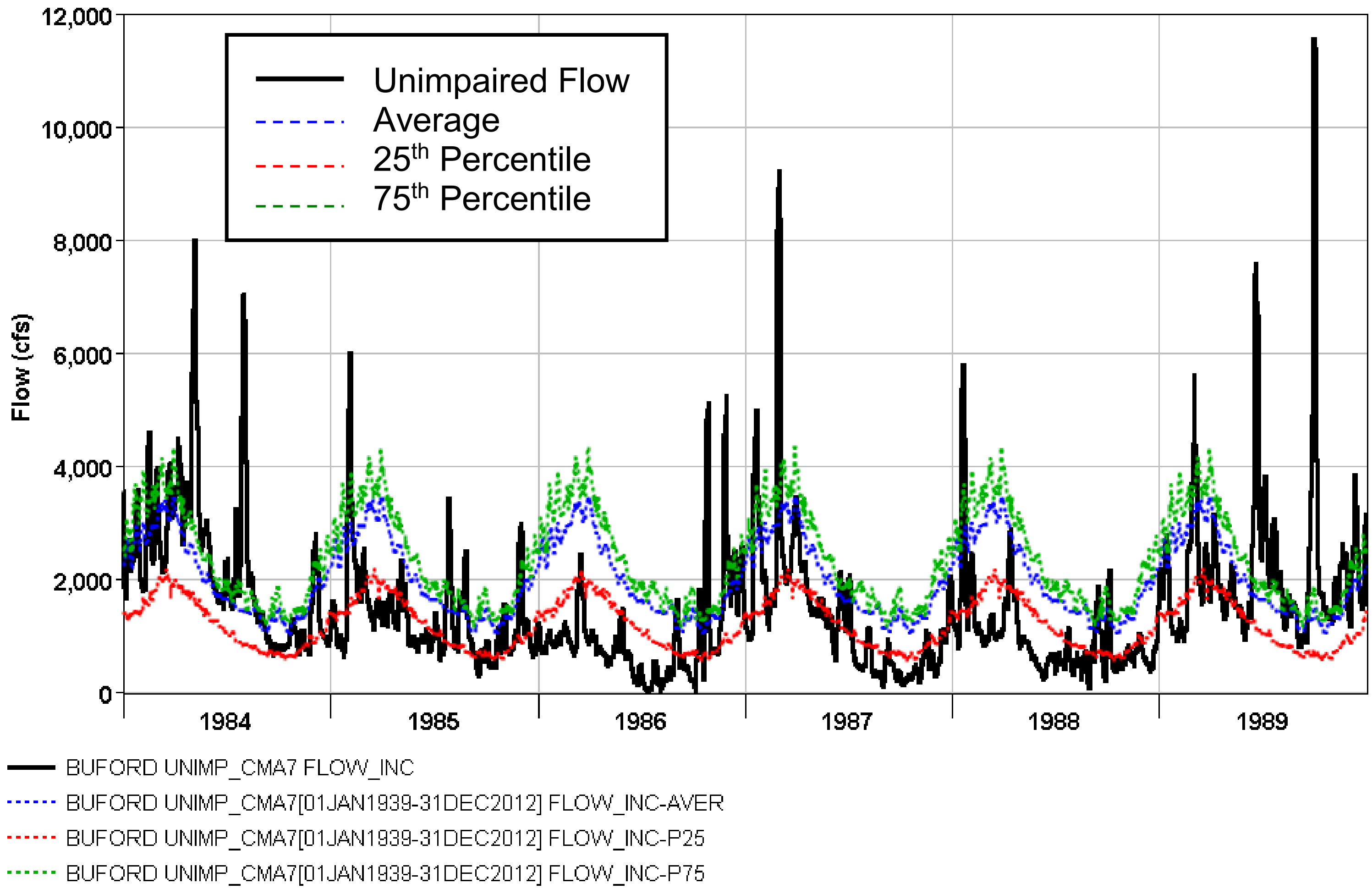


Figure B-15. Buford Unimpaired Inflow – 1980's Drought

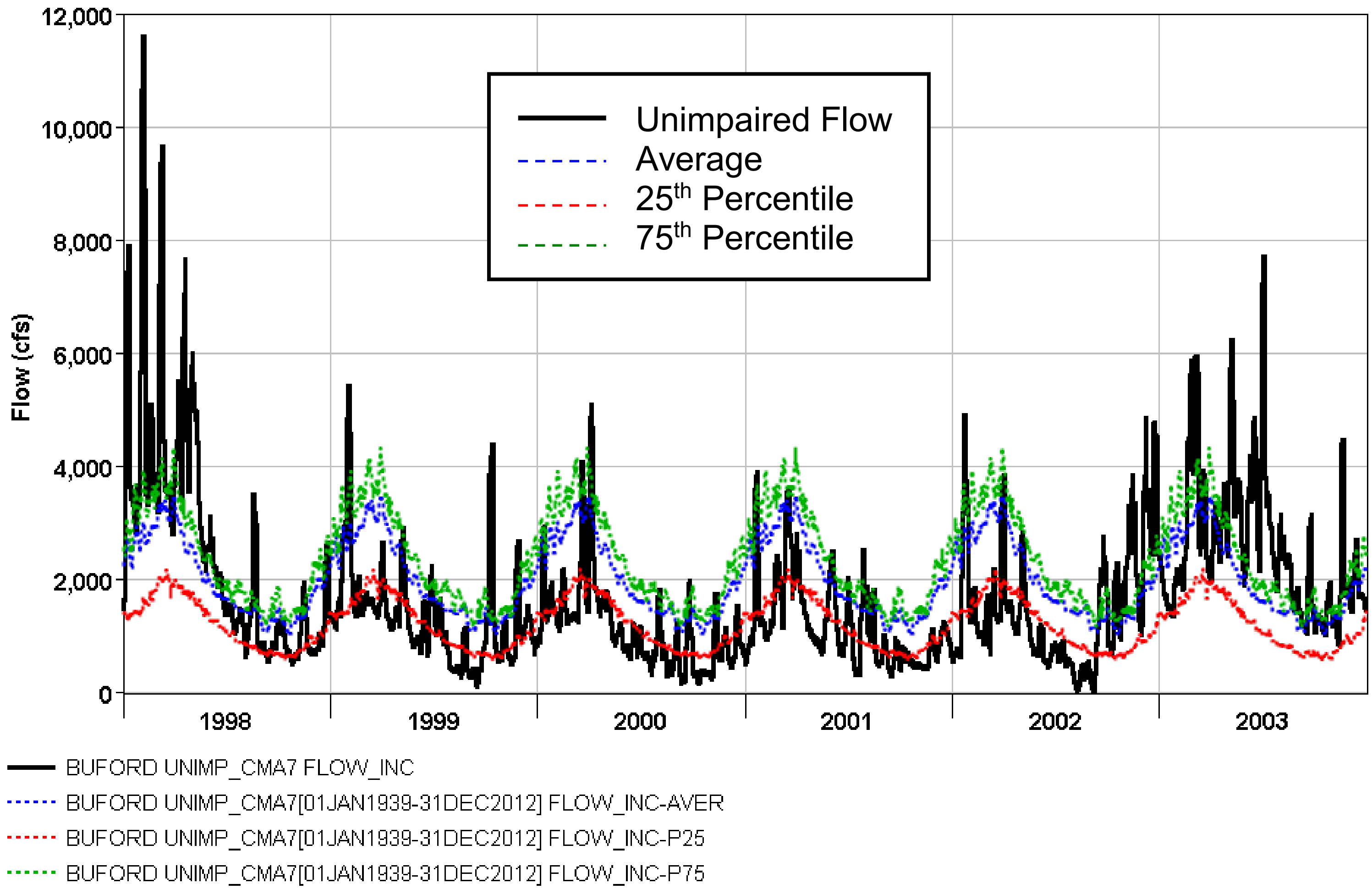


Figure B-16. Buford Unimpaired Inflow – 2000 Drought

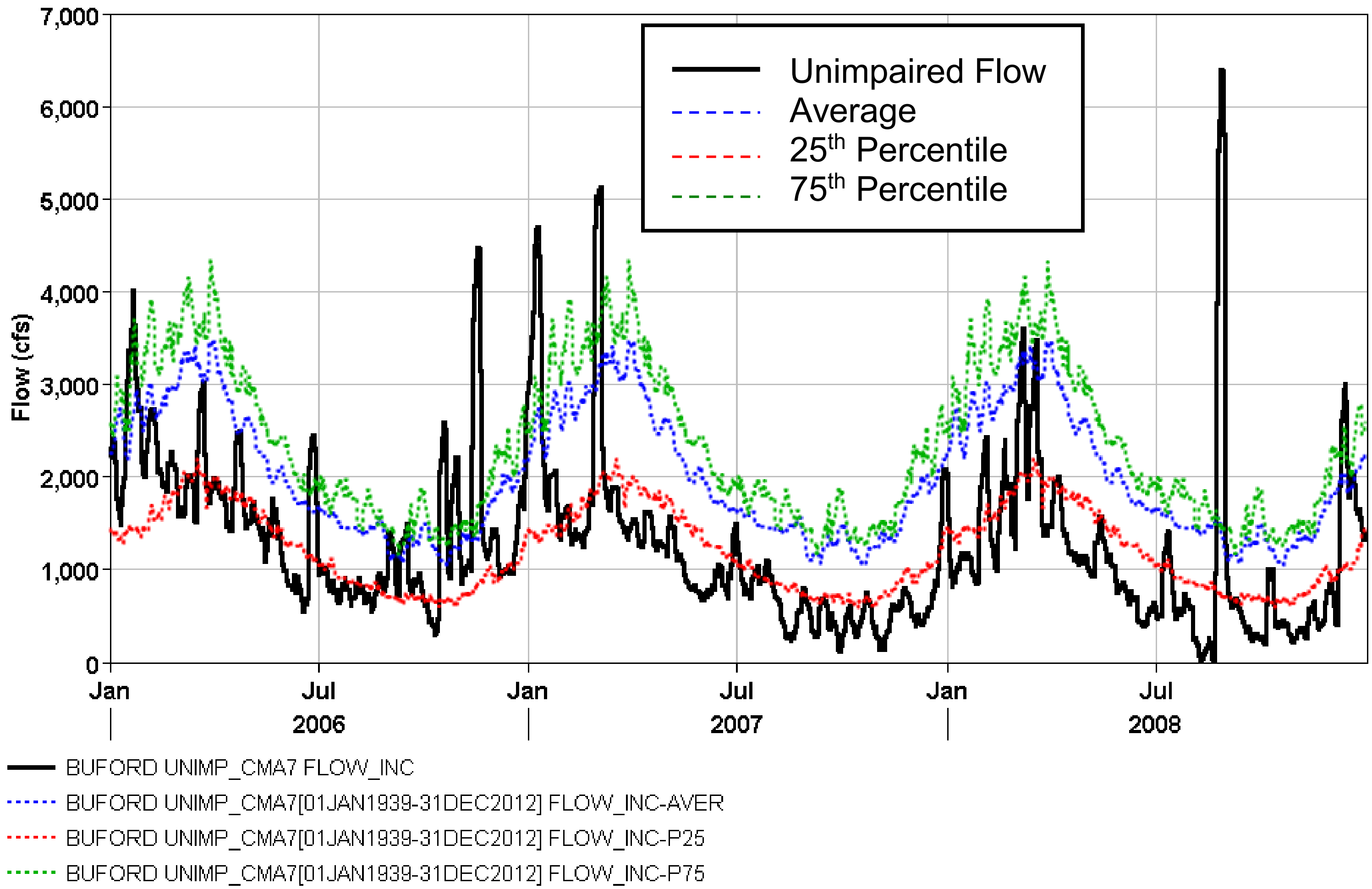


Figure B-17. Buford Unimpaired Inflow – 2007 Drought

1.4 WEST POINT DAM (WEST POINT LAKE)

West Point Dam is located on the Chattahoochee River at mile 201.4 above the mouth and 3.2 miles north of West Point, Georgia. It is 146.9 river miles below Buford Dam, and 126.2 miles above Walter F. George Lock and Dam. The project was completed in May 1975.

West Point Dam is a multiple-purpose project with major project purposes including flood control, hydroelectric power, navigation, recreation, fish and wildlife development and water quality. An aerial photo of the dam is shown in Figure B-18.

Figure B-18. West Point Dam

1.4.1 Drainage Area

The drainage area above the dam is 3,440 square miles. The area is shown on the following Figure B-19.

The operation of Buford Dam reduces peak stages about 10 feet to essentially non-damage stages at Morgan Falls Dam and for several miles downstream. The river bottoms are subject to some overbank flow during the infrequent floods at Vinings and in the northwest suburbs of Atlanta near Bolton. Between Bolton and West Point, a distance of about 100 river miles, there is no urban development in the floodplain.

The Town of Franklin, 37 miles above West Point, is on high ground well above the flood zone. However, the effect of Buford Dam on floods decreases progressively downstream so that at West Point, peak stages are only slightly reduced. The Cities of West Point and Columbus, Georgia, and Lanett, Langdale, Riverview and Phenix City, Alabama, are all subject to flooding. Bankfull channel capacities downstream are 40,000 cfs at West Point and 32,000 cfs at Columbus. The West Point project provides a maximum flood storage of 391,000 acre-feet including the 221,000 acre-feet between elevations 628 and 635 available on a seasonal basis, and the 170,300 acre-feet between elevations 635 and 641 for induced surcharge operations.

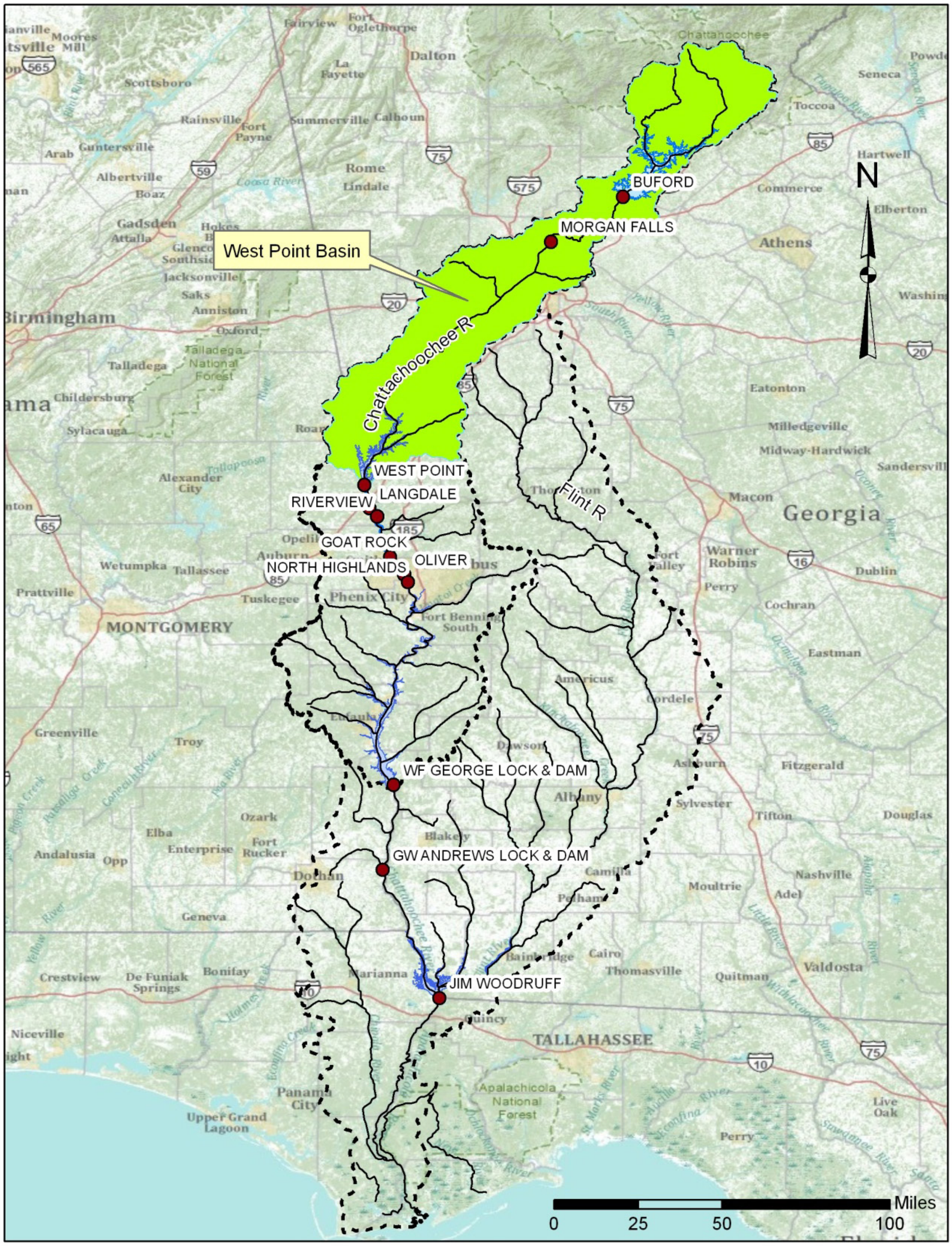


Figure B-19. West Point Basin Map

For the single reservoir yield analysis in this report, only the area below Buford will be used for local inflow to West Point. This drainage area is the difference in the Buford and West Point drainage areas and is equal to 2,400 square miles. This West Point Basin below Buford area is shown in the following Figure B-20.

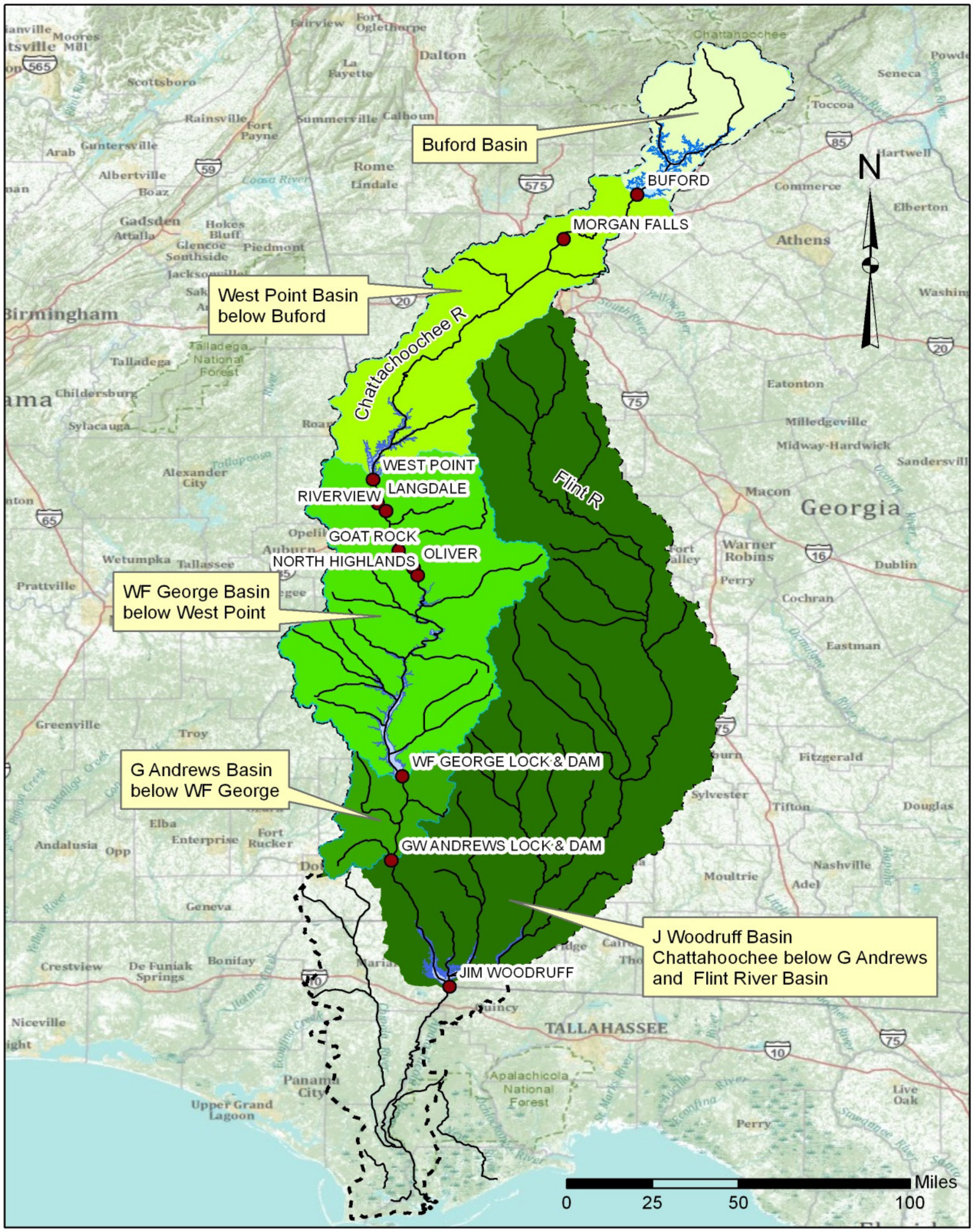


Figure B-20. Incremental Drainage Basin Map for Federal Projects on the ACF

1.4.2 Features

The West Point Dam is a concrete gravity type structure with rolled earthfill embankments joining the high ground on the east and west sides of the river. The total length of the concrete dam and earth embankments is 7,250 feet. At the top of the structures, elevation 652 feet above mean sea level, the length of the concrete portion of the dam is 896 feet. The principal structures that make up the concrete dam are an intake-powerhouse structure, a non-overflow section, a gated spillway located in the main river channel, and a left embankment retaining wall which supports the earth embankment on the east abutment.

1.4.2.1 Non-Overflow Section

The non-overflow section is 185 feet long and forms the tie between the earth embankment on the west side of the river and the powerhouse intake section. The length of the non-overflow is determined by the clearance required between the terminal cone slopes and the powerhouse intake.

1.4.2.2 Spillway Section

The spillway section is a gravity type ogee section 350 feet long with crest at elevation 597. The spillway contains six tainter gates, each 50 feet wide and 41 feet high, between 10-foot thick piers supported on the overflow section.

1.4.2.3 Powerhouse and Intake

The powerhouse and intake structure are integrated into a reinforced concrete unit which acts as a part of the dam. The structure is 321 feet in length and consists of five monoliths located between the spillway and non-overflow section. The intake structure provides waterway openings for three main generating units (two to be installed initially and one for a future unit) and one small generating unit to provide continuous minimum flow releases. The main turbines are propeller type with concrete semi-spiral cases. The small was selected to give maximum efficiency while discharging 675 cfs at any head.

1.4.2.4 Reservoir

The reservoir has a total storage capacity of 774,800 acre-feet at full flood control pool, elevation 641 feet, and covers an area of 31,800 acres. At full conservation pool, elevation 635 feet, the reservoir covers 25,900 acres and has a total storage capacity of 604,500 acre-feet; at minimum conservation pool, elevation 620 feet, the area covered is 15,500 acres with storage capacity of 298,400 acre-feet. Area-capacity curves are shown on Table B-6 and Figure B-21. Conservation storage varies seasonally from 143,900 acre-feet to 306,100 acre-feet between a minimum elevation of 620 feet and a top of conservation pool elevation varying from 628 to 635 feet. Although the top of the flood control pool is 641 feet, only the conservation pool will be used in the yield analysis.

Table B-6. West Point Reservoir Area and Capacity (circa 1975)

Pool Elev (ft NGVD 29)	Total Area (ac)	Total Storage (ac-ft)
*620	15,512	298,396
621	16,100	314,202
622	16,702	330,602
623	17,318	347,612
624	17,949	365,245
625	18,593	383,515
626	19,252	402,437
627	19,926	422,025
**628	20,615	442,295
629	21,318	463,260
630	22,037	484,937
631	22,771	507,340
632	23,520	530,485
633	24,286	554,387
634	25,067	579,062
***635	25,864	604,527
636	26,677	630,796
637	27,507	657,887
638	28,353	685,816
639	29,216	714,600
640	30,096	744,254
****641	30,993	774,798
642	31,907	806,246
643	32,838	838,618
644	33,788	871,930
645	34,755	906,200

* Minimum power pool
** Top of power pool - December through April
*** Top of power pool - June through October
**** Top of flood control pool

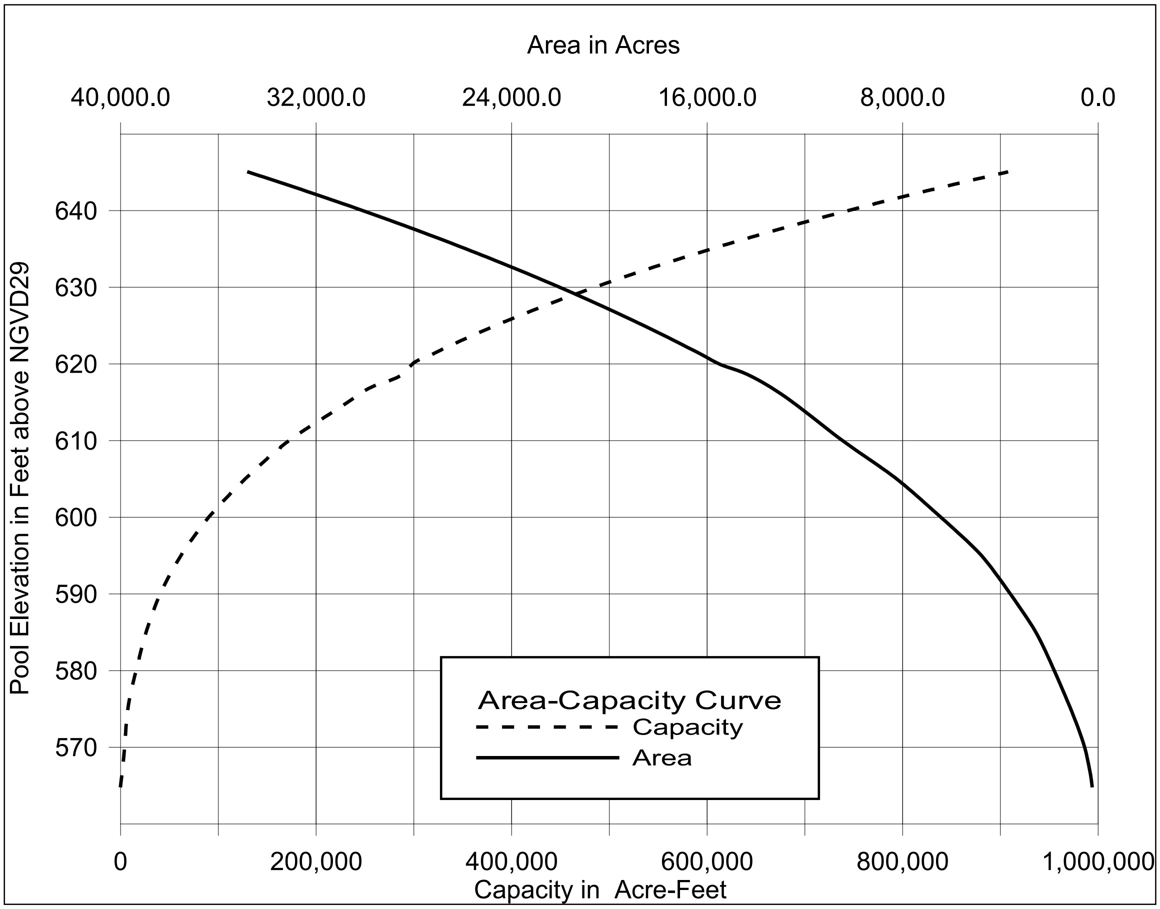


Figure B-21. West Point Area – Capacity Curves (circa 1975)

1.4.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 628 to 635 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 635 from 1 June through 1 November, then decrease to 628 feet by 15 December, then hold 628 feet unti1 15 February, and then increase to 635 feet by 1 June, as shown in Figure B-22.

1.4.4 Regulation Plan

Normally the West Point project will be operated as a peaking plant for the production of hydroelectric power and will maintain a continuous flow of 675 cfs during off-peak periods. During low-water periods, such regulation will provide increased flow downstream for navigation, water supply, water quality requirements and other purposes.

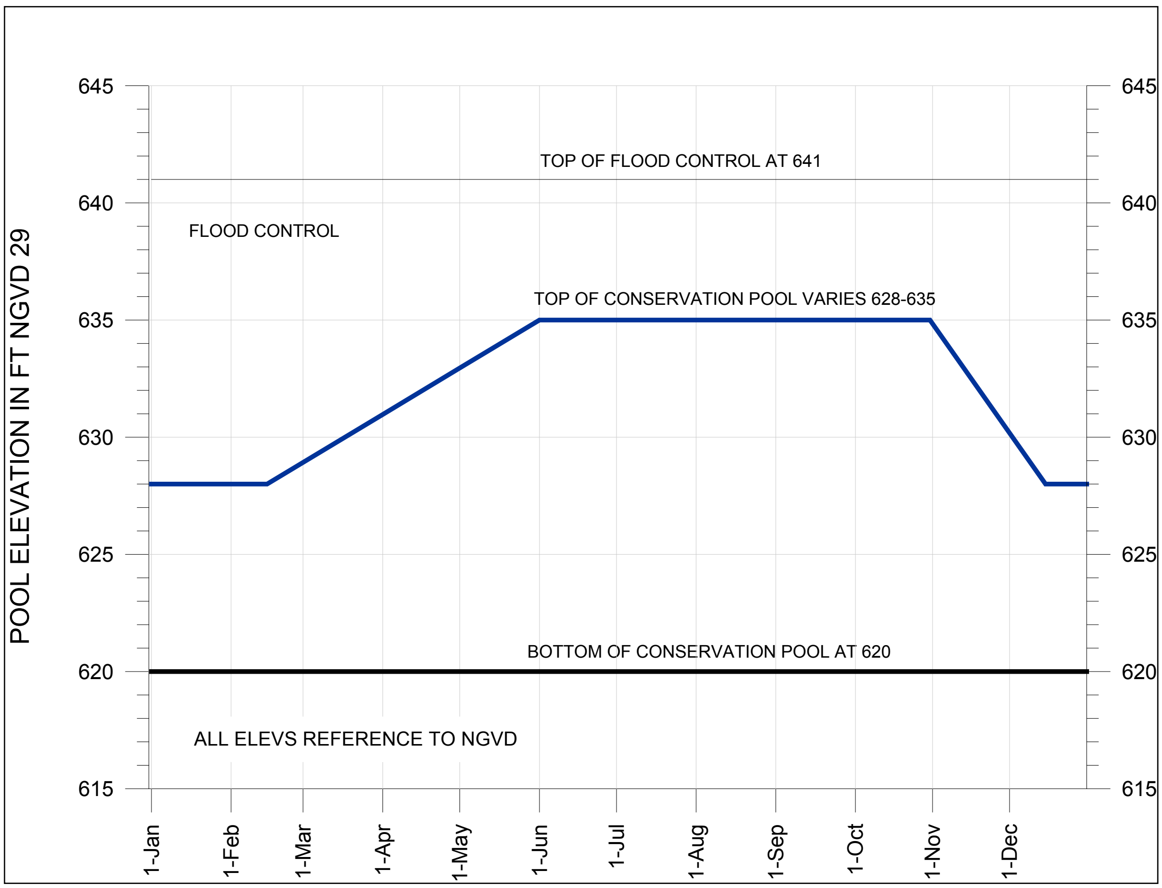


Figure B-22. Top and Bottom of West Point Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 635 (or 628 depending on the time of year) to 620.

1.4.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in May 1975, just as the pool was filling, through 2011 are available. The data are presented in the following Figure B-23.

1.4.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2011 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2011 is shown in Figure B-24. Daily flows for critical drought periods are plotted in more detail in Figures B-25 – B-29.

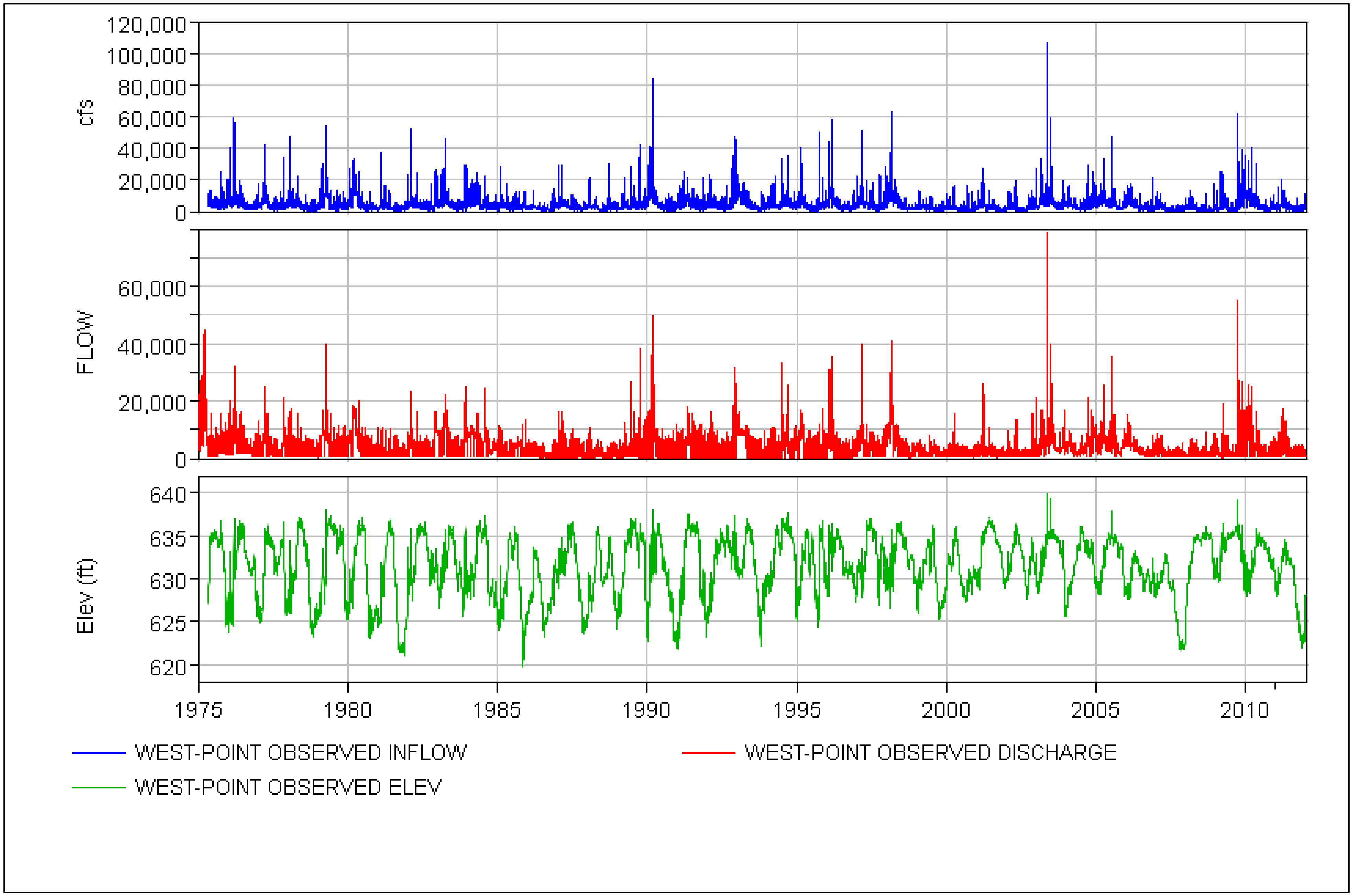


Figure B-23. West Point Inflow-Outflow-Pool Elevation (Jan 1975-Dec 2009)

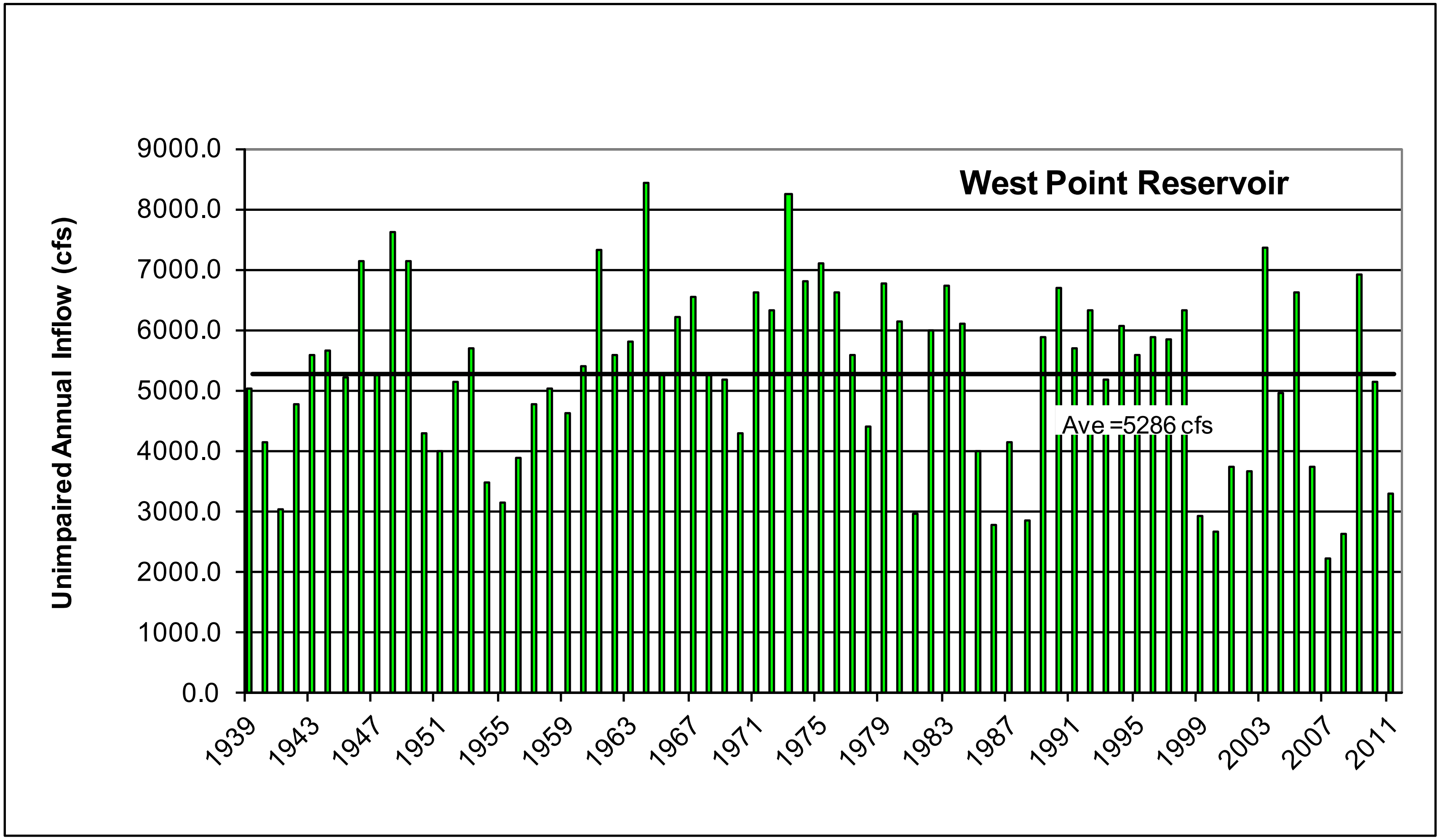


Figure B-24. West Point Unimpaired Annual Inflow Jan 1939 to Dec 2011

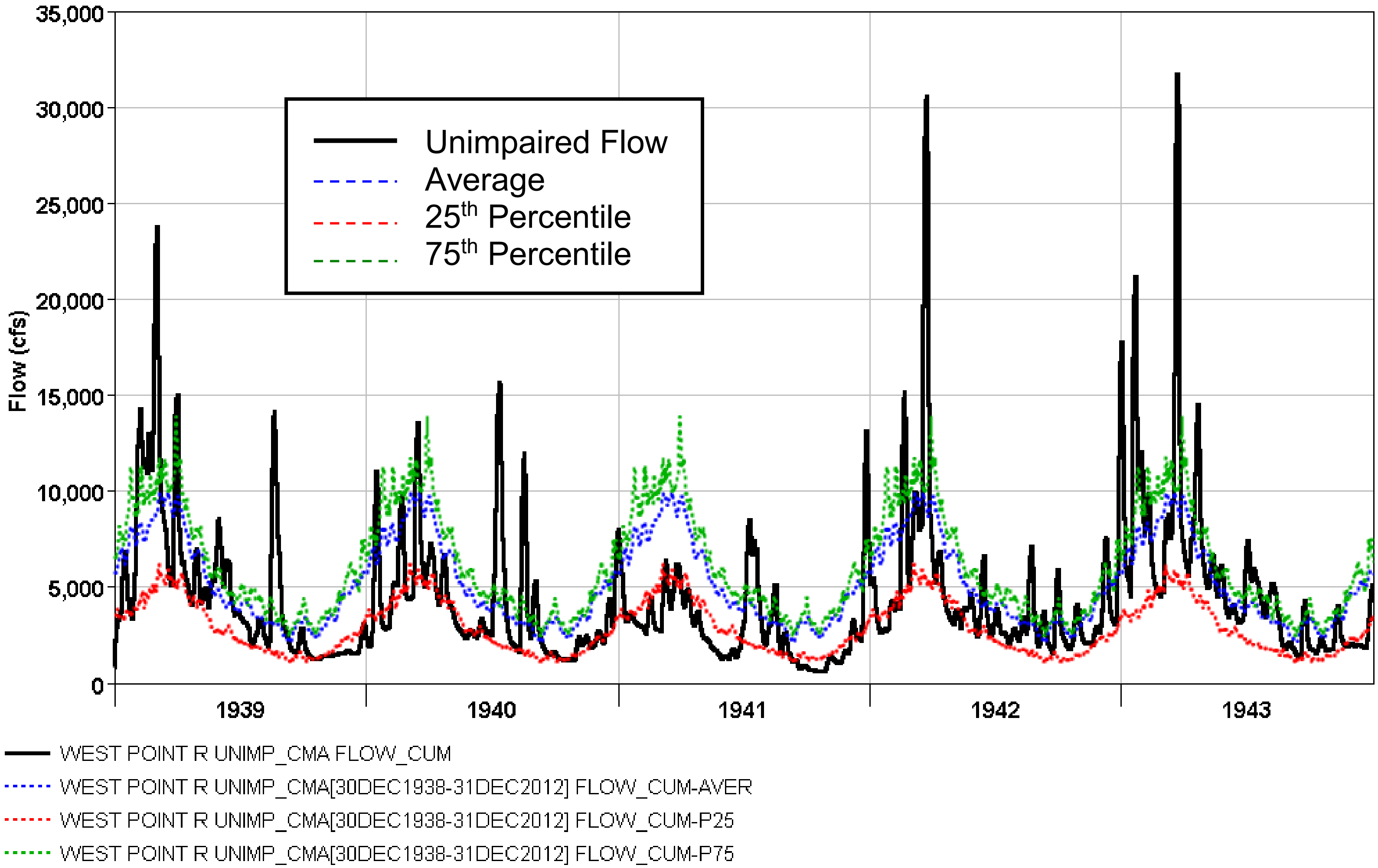


Figure B-25. West Point Unimpaired Inflow – 1940's Drought; 75th Percentile, Average and 25th Percentile Flow

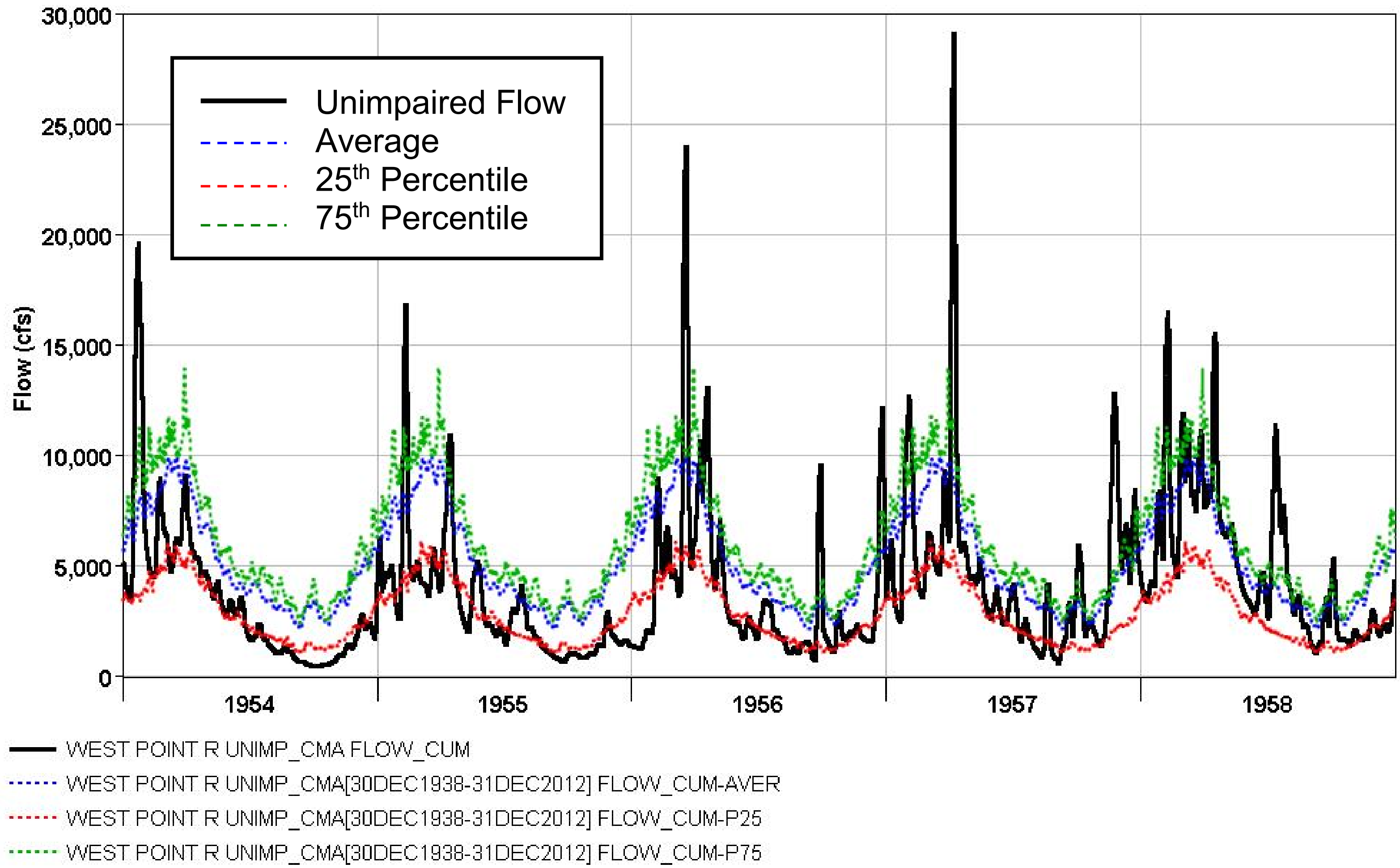


Figure B-26. West Point Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

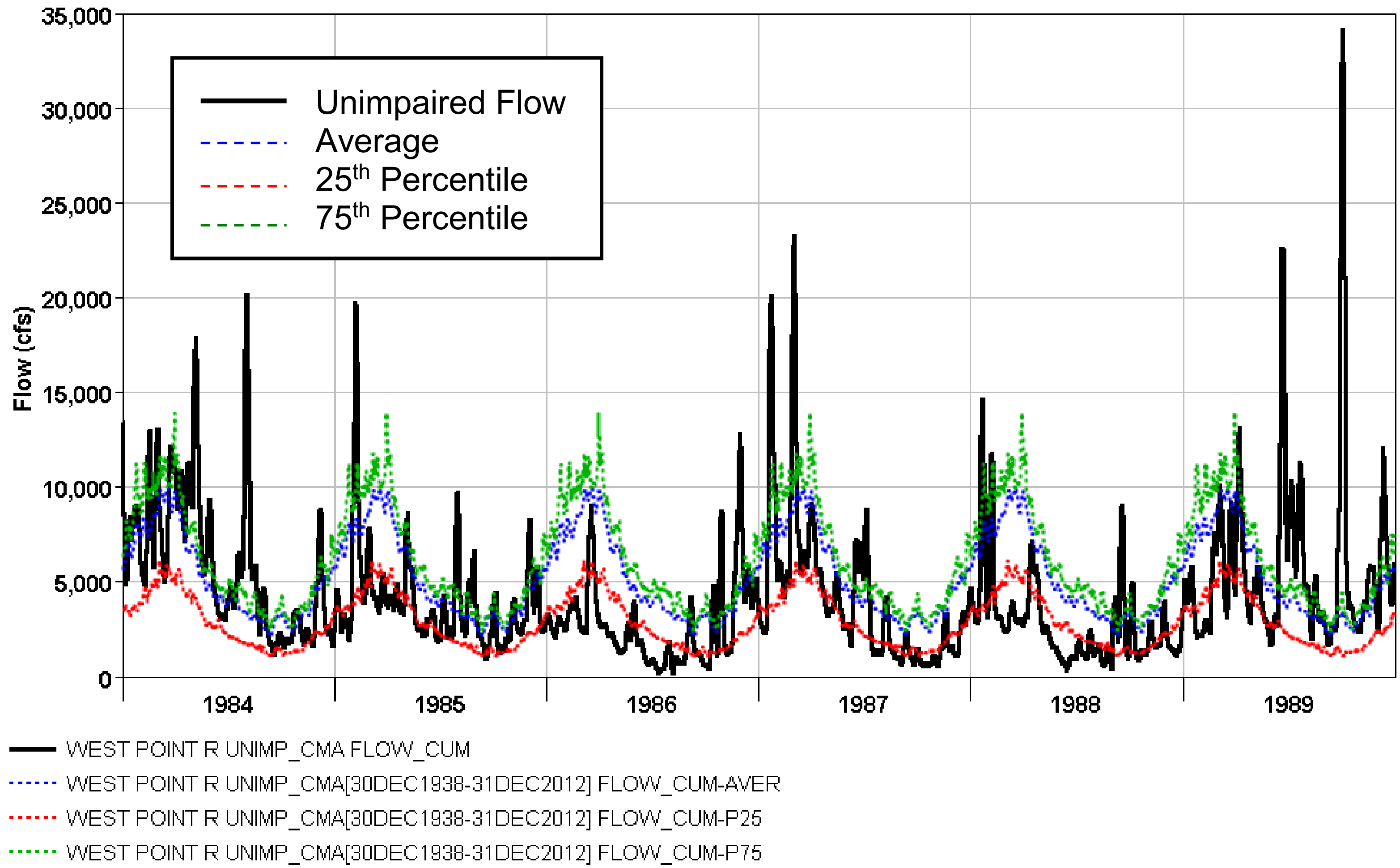


Figure B-27. West Point Unimpaired Inflow – 1980's Drought; 75th Percentile, Average and 25th Percentile Flow

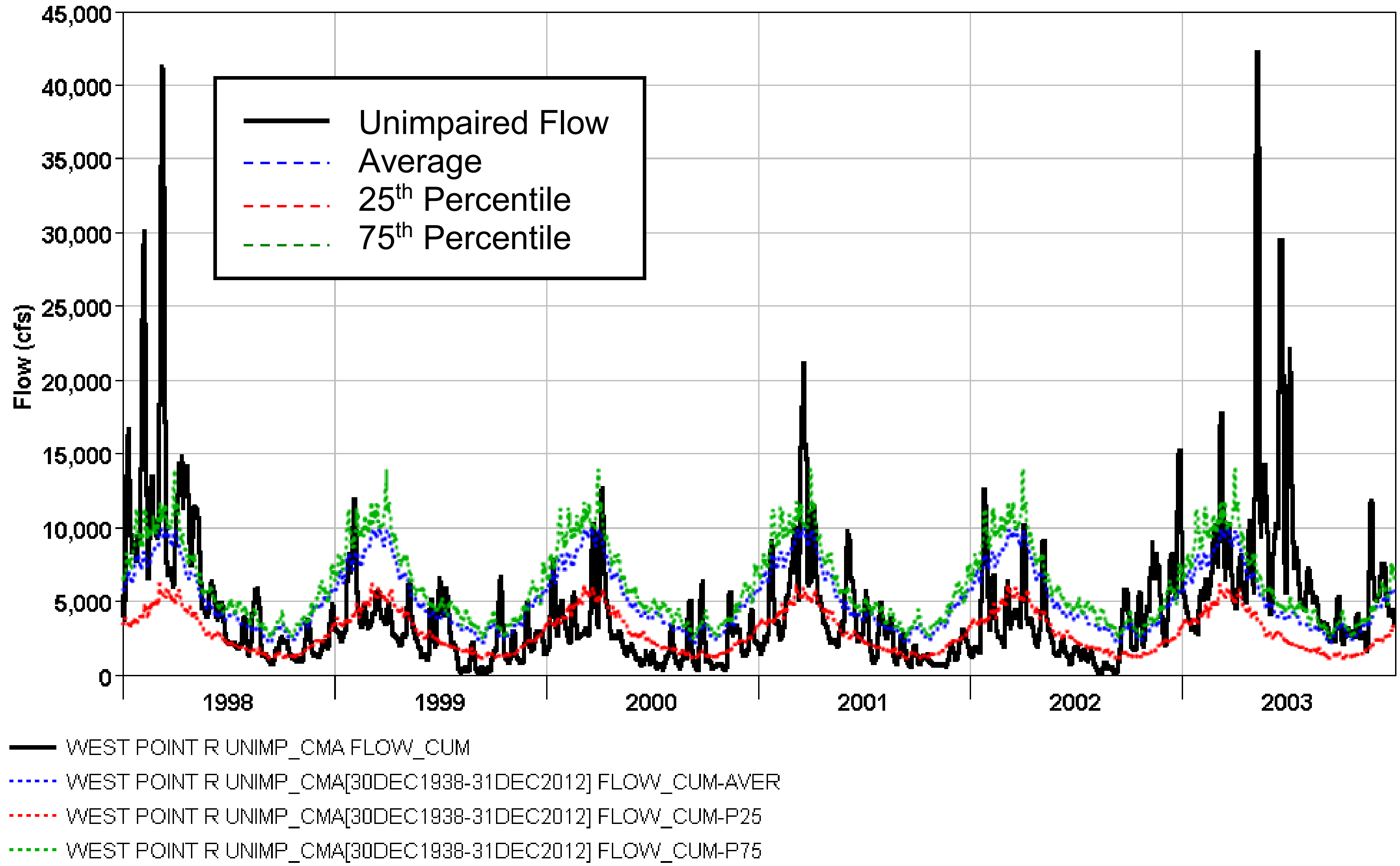


Figure B-28. West Point Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

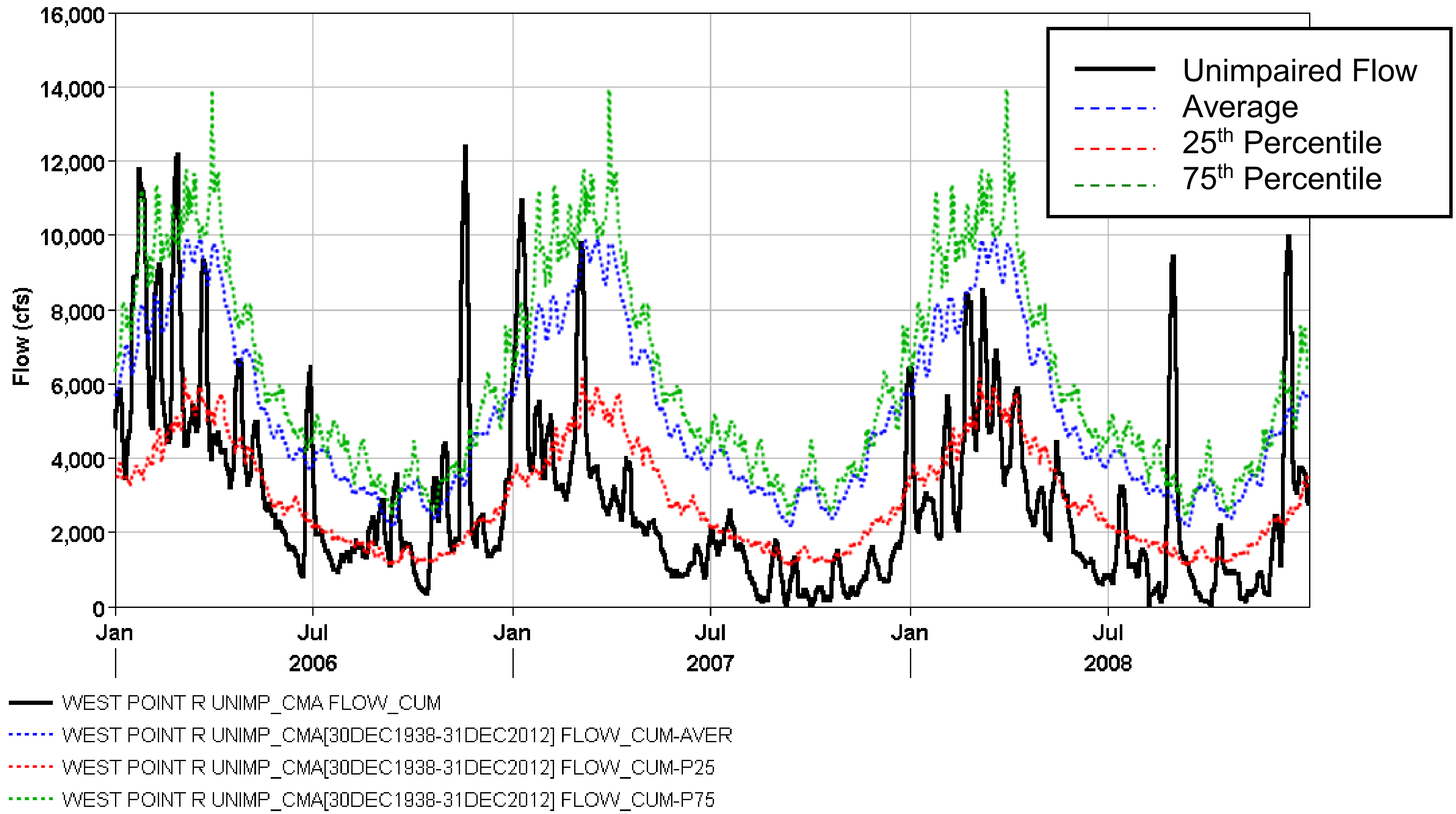


Figure B-29. West Point Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

1.5 WALTER F. GEORGE DAM AND RESERVOIR

Walter F. George Lock and Dam is located on the Chattahoochee River at mile 75, approximately one mile north of Fort Gaines, Georgia and approximately 1.6 miles upstream from the Georgia State Highway 37 bridge. The dam crosses the Alabama-Georgia state line with the earth dike on the west bank entirely in Henry County, Alabama. The earth dike on the east is entirely in Clay County, Georgia. The project was completed in June 1963.

Walter F. George Dam is a multiple-purpose project with major project purposes including, hydroelectric power, navigation, recreation, fish and wildlife development and water quality. The project was not designed for flood control. An aerial photo of the dam is shown in Figure B-30.

Figure B-30. Walter F. George Dam

1.5.1 Drainage Area

The drainage area above Walter F. George Lock and Dam is 7,460 square miles. In the drainage area above Walter F. George Lock and Dam there are nine power developments and two multiple-purpose dams. Seven of the power projects are owned and operated by the Georgia Power Company. They are: Morgan Falls, Langdale, Riverview, Bartletts Ferry, Goat Rock, Oliver, and North Highlands. . Buford and West Point Dams are federal projects operated by the Corps of Engineers and are multiple-purpose dams that provide flood protection, production of hydroelectric power, water supply, recreation, instream flow, and increased flows for navigation during low-flow seasons. The drainage area and federal and Georgia Power Company dams are shown on the following Figure B-31.

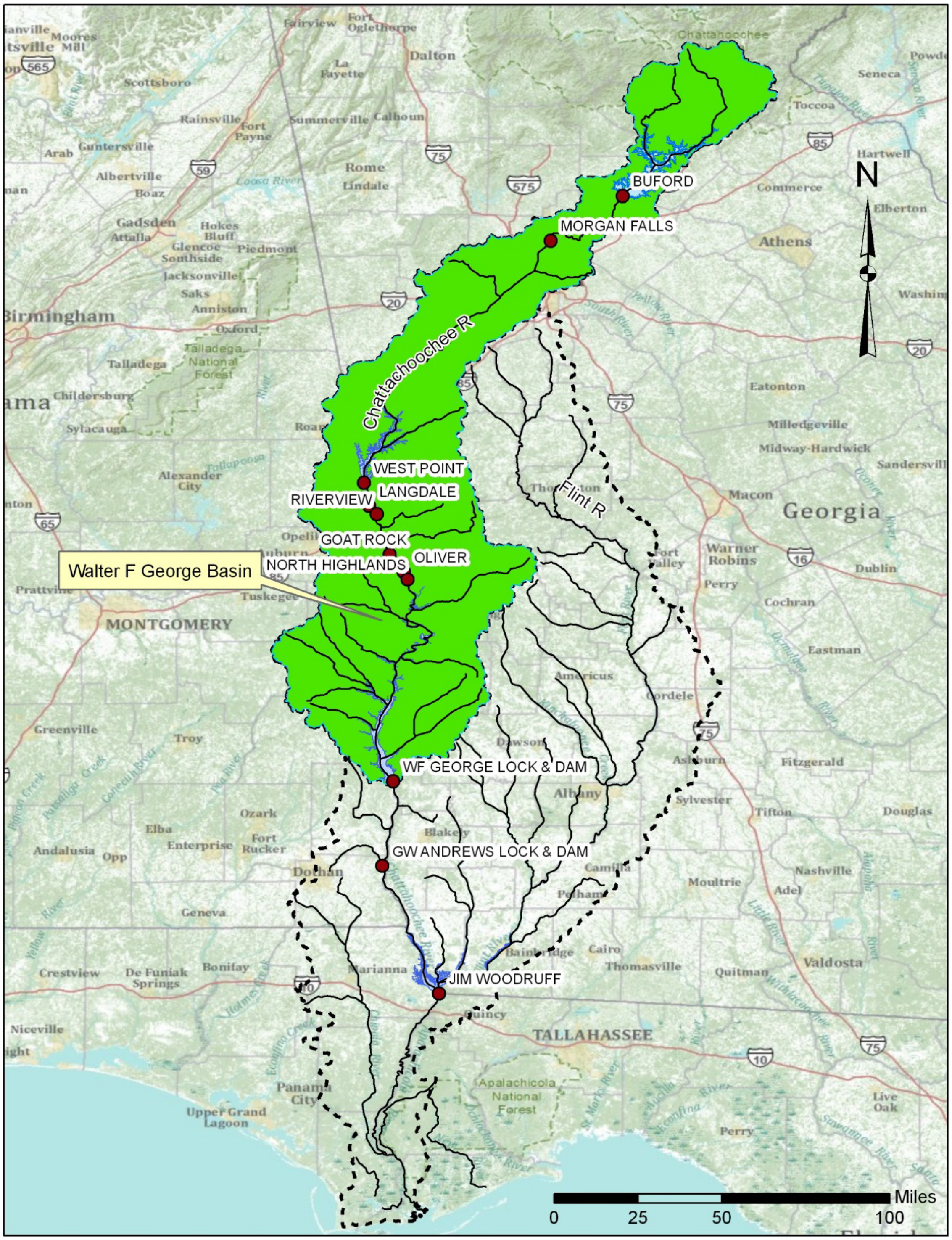


Figure B-31. Walter F. George Basin Map

For the single reservoir yield analysis in this report, only the area below West Point was used for local inflow to Walter F. George. This drainage area is the difference in the West Point and Walter F. George drainage areas and is equal to 4,020 square miles. This Walter F. George Basin below West Point area is shown in the following Figure B-32.

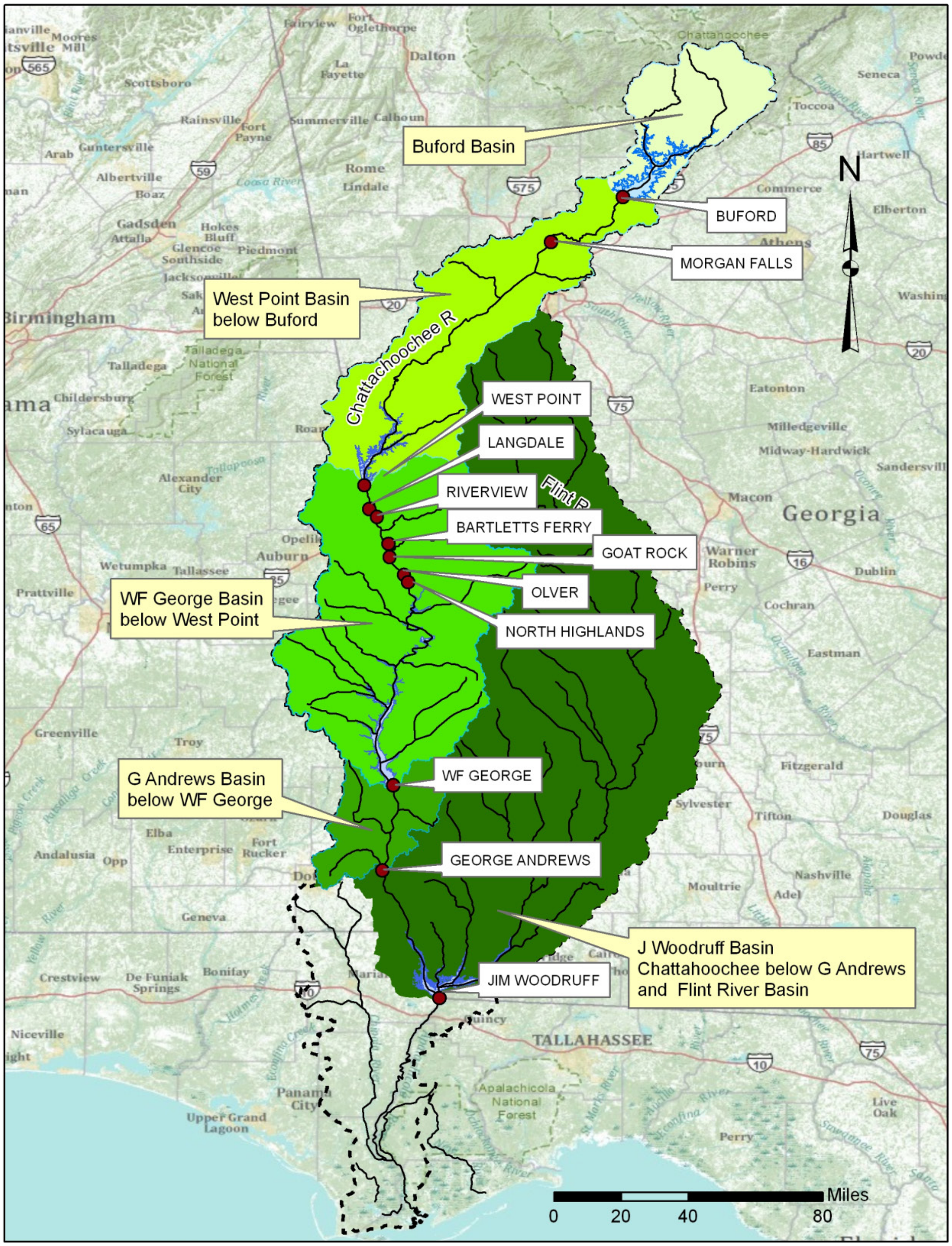


Figure B-32. Incremental Drainage Basin Map for Federal Projects on the ACF

1.5.2 General Features

The dam consists of a powerhouse, a gated spillway, a lock in and adjacent to the original river channel, and earth dikes extending to high ground on both banks. The lock is 82 by 450 feet with a maximum lift of 88 feet. The project has a 130,000 kW power plant with appurtenances, and a reservoir extending up the Chattahoochee River 85 miles to Columbus, Georgia and Phenix City, Alabama. The reservoir provides a nine-foot minimum depth for navigation from the dam to Columbus and Phenix City. The principal features of the structure are, from left to right bank, an earth dike, the navigation lock, the concrete gated spillway, the powerhouse with intake section constituting part of the dam, and an earth dike.

1.5.2.1 Dam

Overall length of the structure including the lock and powerhouse sections is 13,585 feet, or 2.6 miles.

1.5.2.2 Reservoir

The reservoir at maximum summer operating level (conservation pool) of elevation 190, covers an area of 45,180 acres and has a total storage of 934,400 acre-feet. The pool extends up the Chattahoochee River 85 miles to Columbus, Georgia. At the minimum operating level (conservation pool), elevation 184, the reservoir covers an area of 36,375 acres and has a total storage of 690,000 acre-feet. Area and capacity curves are shown on Figure B-33 and in Table B-7.

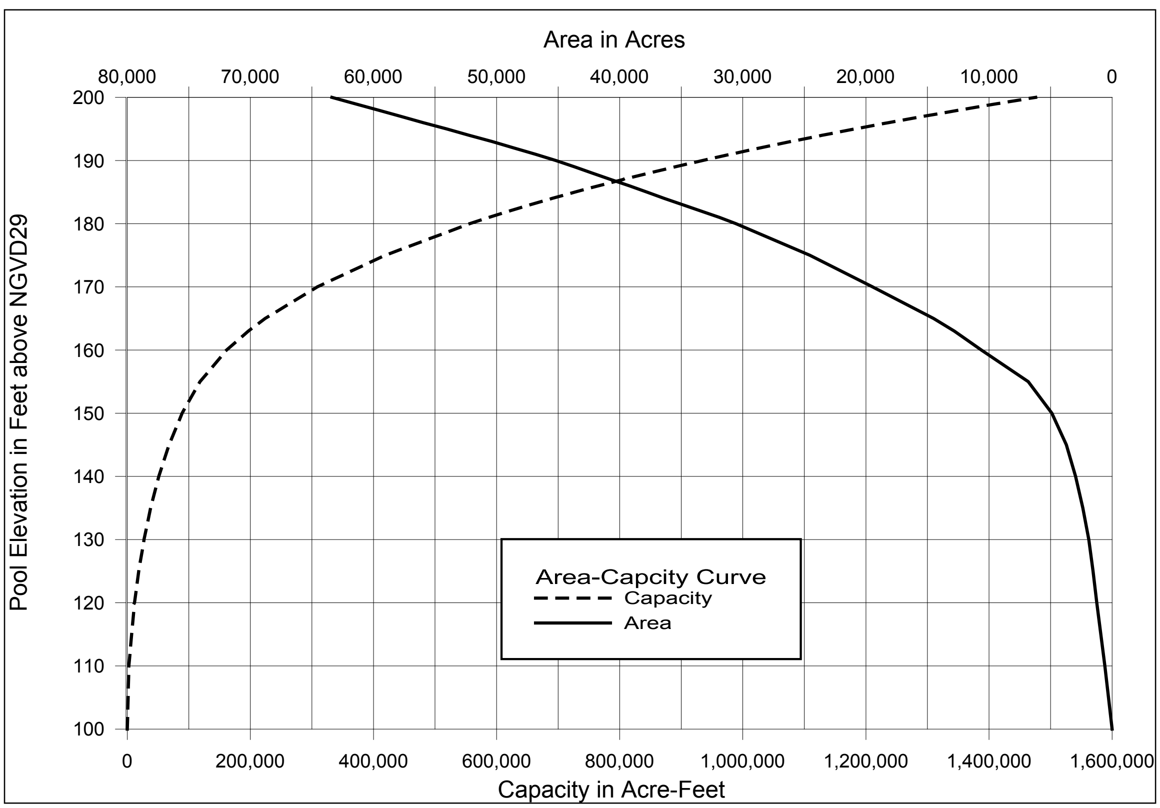


Figure B-33. Walter F. George Area – Capacity Curves (circa 1965)

Table B-7. Walter F. George Reservoir Area and Capacity (circa 1965)

Pool Elev (ft NGVD 29	Total Area (ac)	Total Storage (ac-ft)
100	8	10
105	248	550
110	587	2,610
115	902	6,340
120	1,248	11,680
125	1,550	18,670
130	1,894	27,240
135	2,375	37,920
140	2,966	51,210
145	3,720	67,830
150	4,895	89,100
155	6,815	118,140
160	10,624	161,500
*163	12,815	196,700
165	14,501	224,000
170	19,457	308,700
175	24,556	419,000
180	30,577	556,300
181	31,897	587,600
182	33,396	620,200
183	34,880	654,400
184	36,375	690,000
185	37,784	727,100
186	39,210	765,600
187	40,735	805,500
**188	42,210	847,100
189	43,665	890,000
***190	45,181	934,400
191	46,850	980,500
192	48,615	1,028,100
193	50,356	1,077,600
194	52,250	1,129,000
195	54,045	1,182,100
196	55,975	1,237,100
197	57,800	1,294,000
198	59,650	1,352,700
199	61,528	1,413,300
200	63,375	1,475,800

* Crest of gated spillway
** Top of power pool - December through April
*** Top of power pool - June through September

1.5.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 188 to 190 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 190 from 1 June through 31 October, then decrease to 188 feet by 1 December, then hold 188 feet unti1 1 May, and then increase to 190 feet by 1 June, as shown in Figure B-34.

1.5.4 Regulation Plan

The Walter F. George pool is regulated between the minimum pool elevation 184 and 190. The pool may rise above elevation 190 for short periods of time during high flow periods. A major operating constraint is the structural limitation that the difference between the headwater and tailwater must not exceed 88 feet at any time. In addition to reservoir constraints, downstream water needs will, at times, require outflow from Walter F. George to be fairly evenly distributed throughout each week.

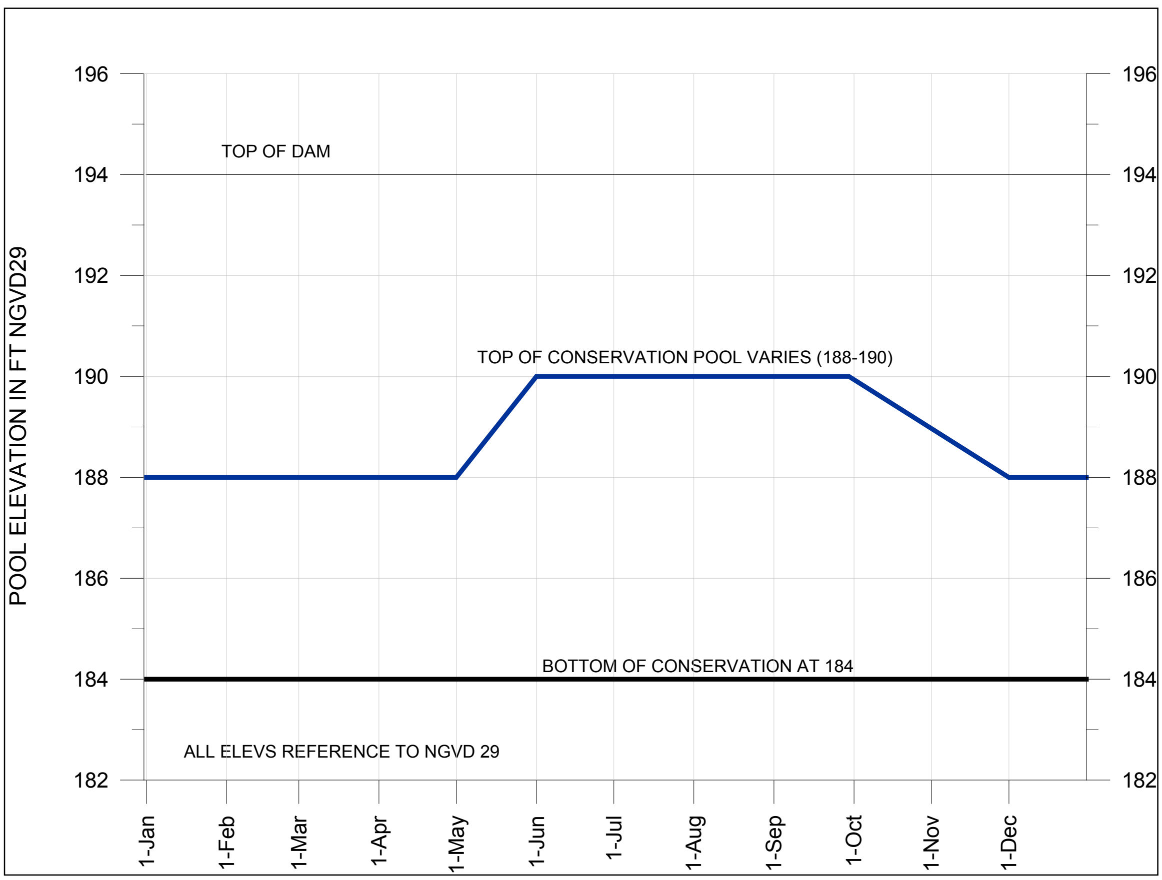


Figure B-34. Top and Bottom of Walter F. George Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 184 to 188 - 190 (depending on the time of year).

1.5.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in January 1964, just after the pool filled, through 2011 are available. The data are presented in the following Figure B-35.

1.5.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2011 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2011 is shown in Figure B-36. Daily flows for critical drought periods are plotted in more detail in Figures B-37 – B-41.

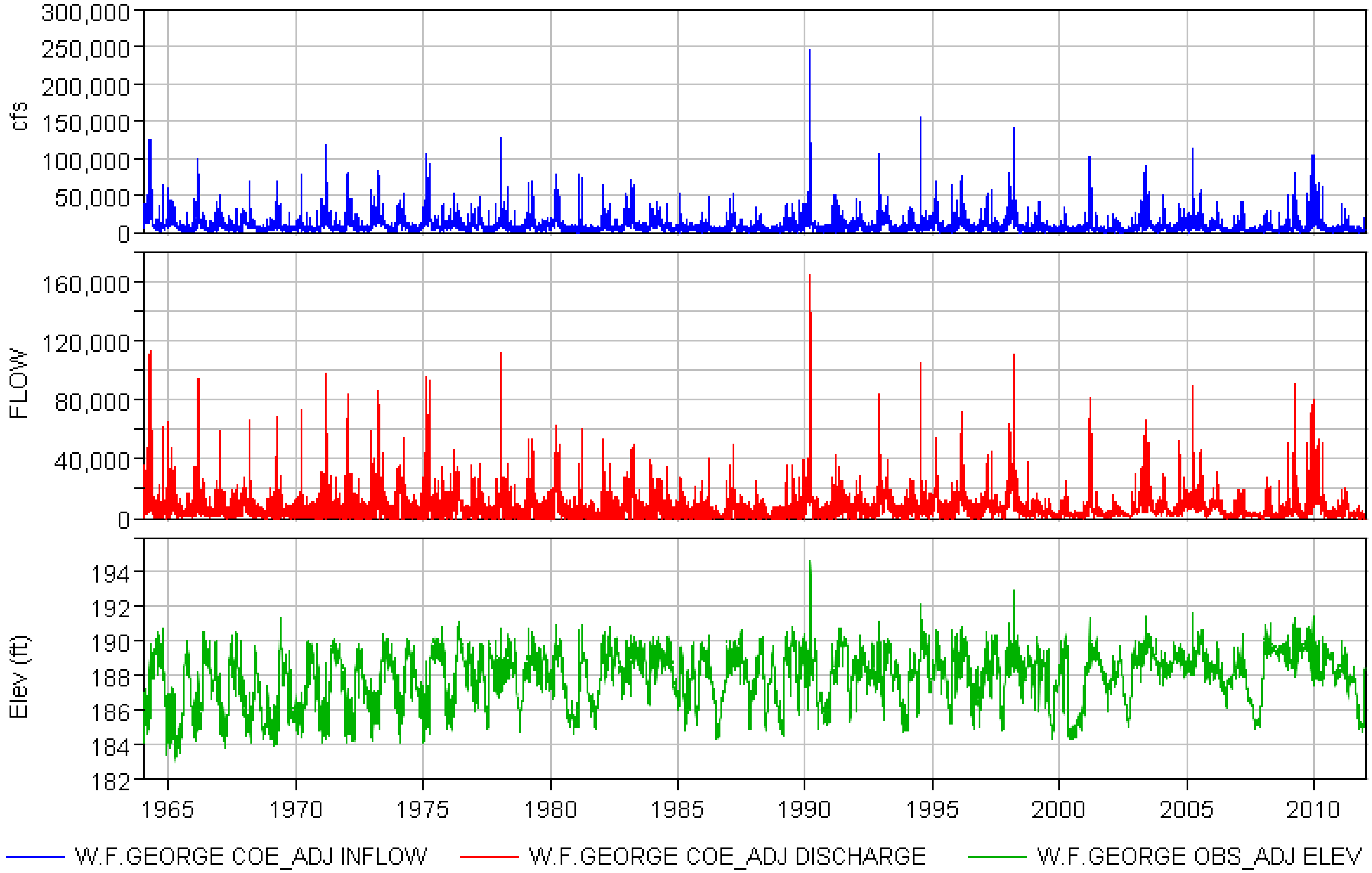


Figure B-35. Walter F. George Inflow-Outflow-Pool Elevation (Jan 1964-Dec 2011)

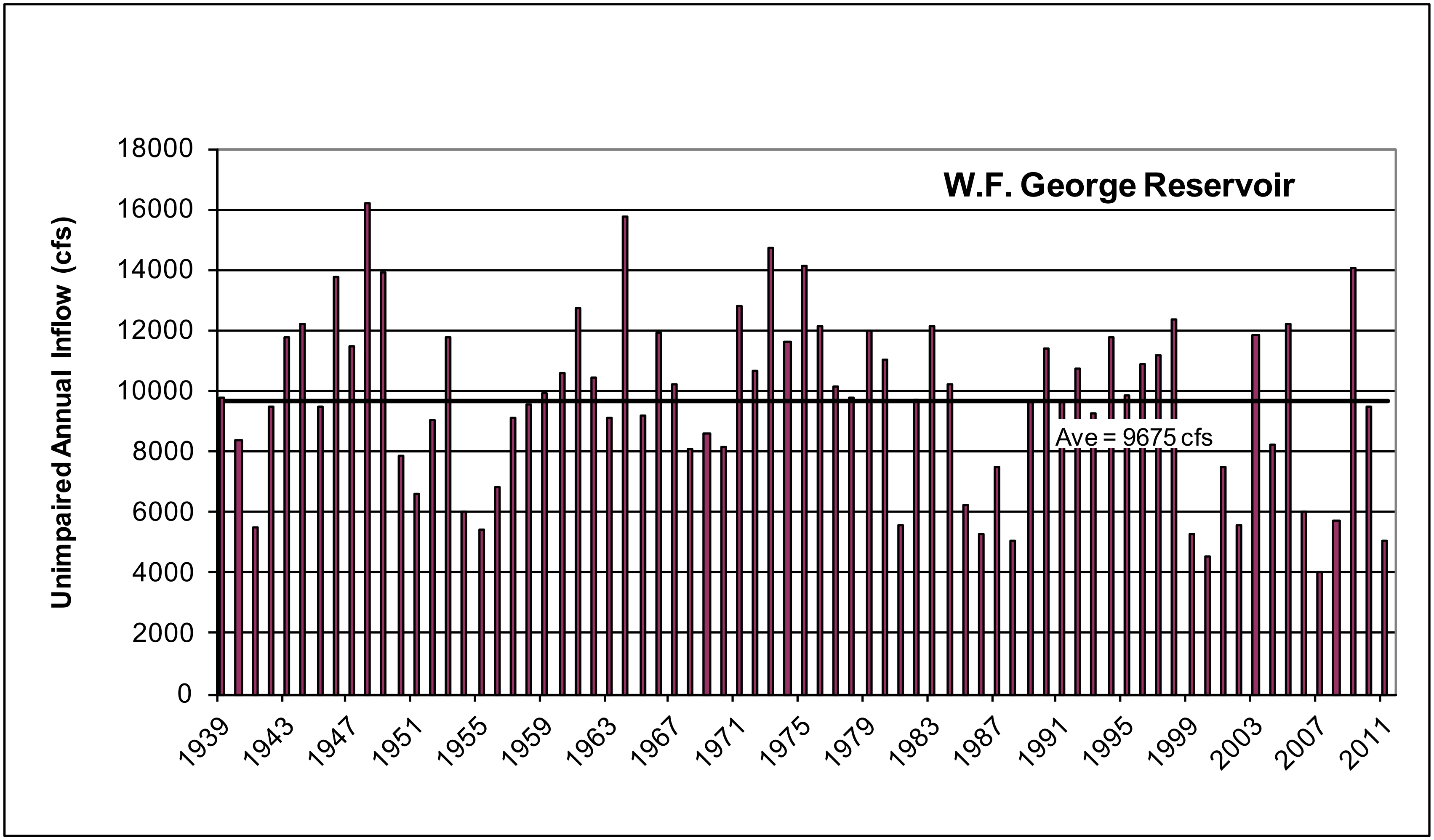


Figure B-36. Walter F. George Unimpaired Annual Inflow Jan 1939 to Dec 2011

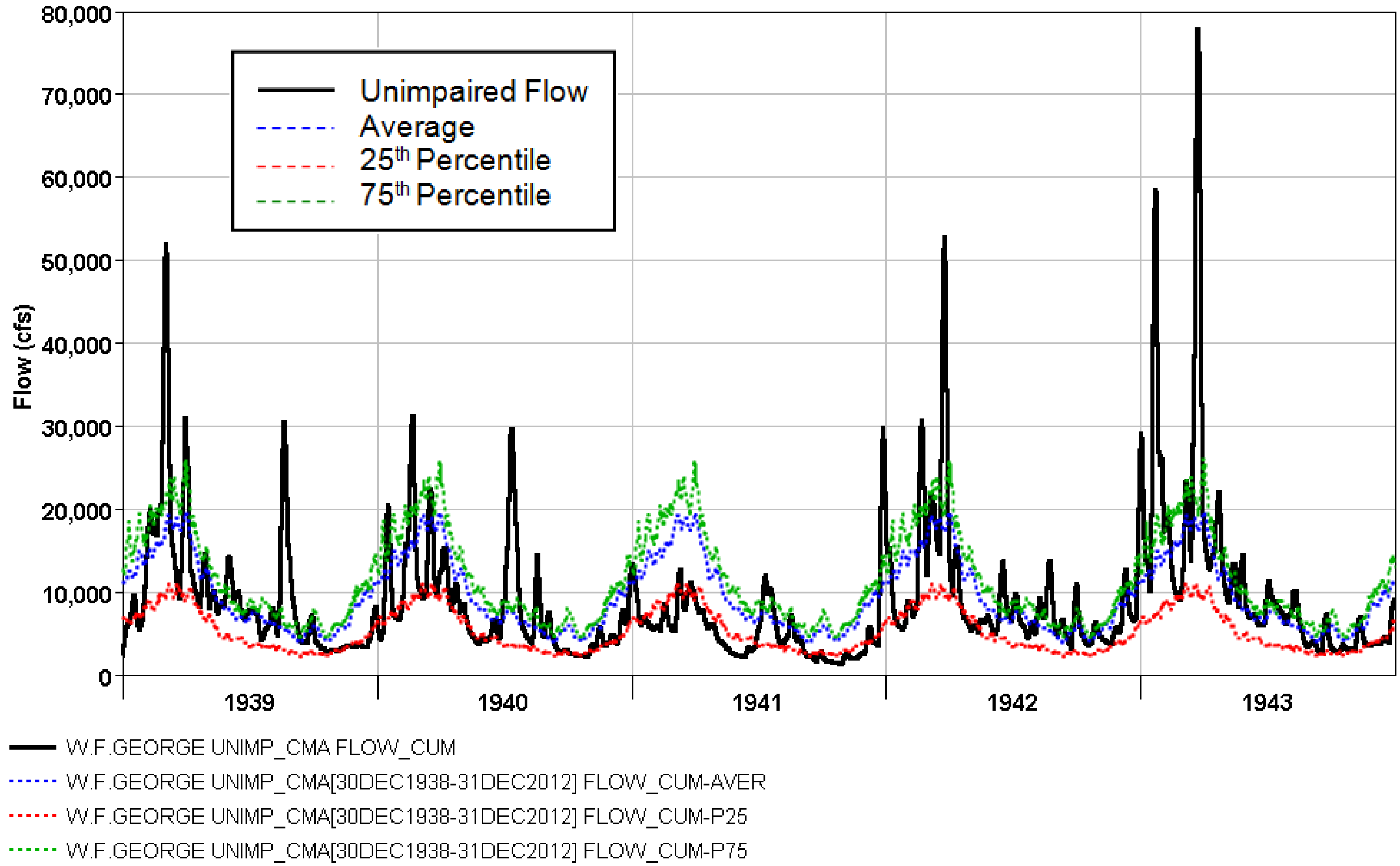


Figure B-37. Walter F. George Unimpaired Inflow – 1940's Drought; 75th Percentile, Average and 25th Percentile Flow

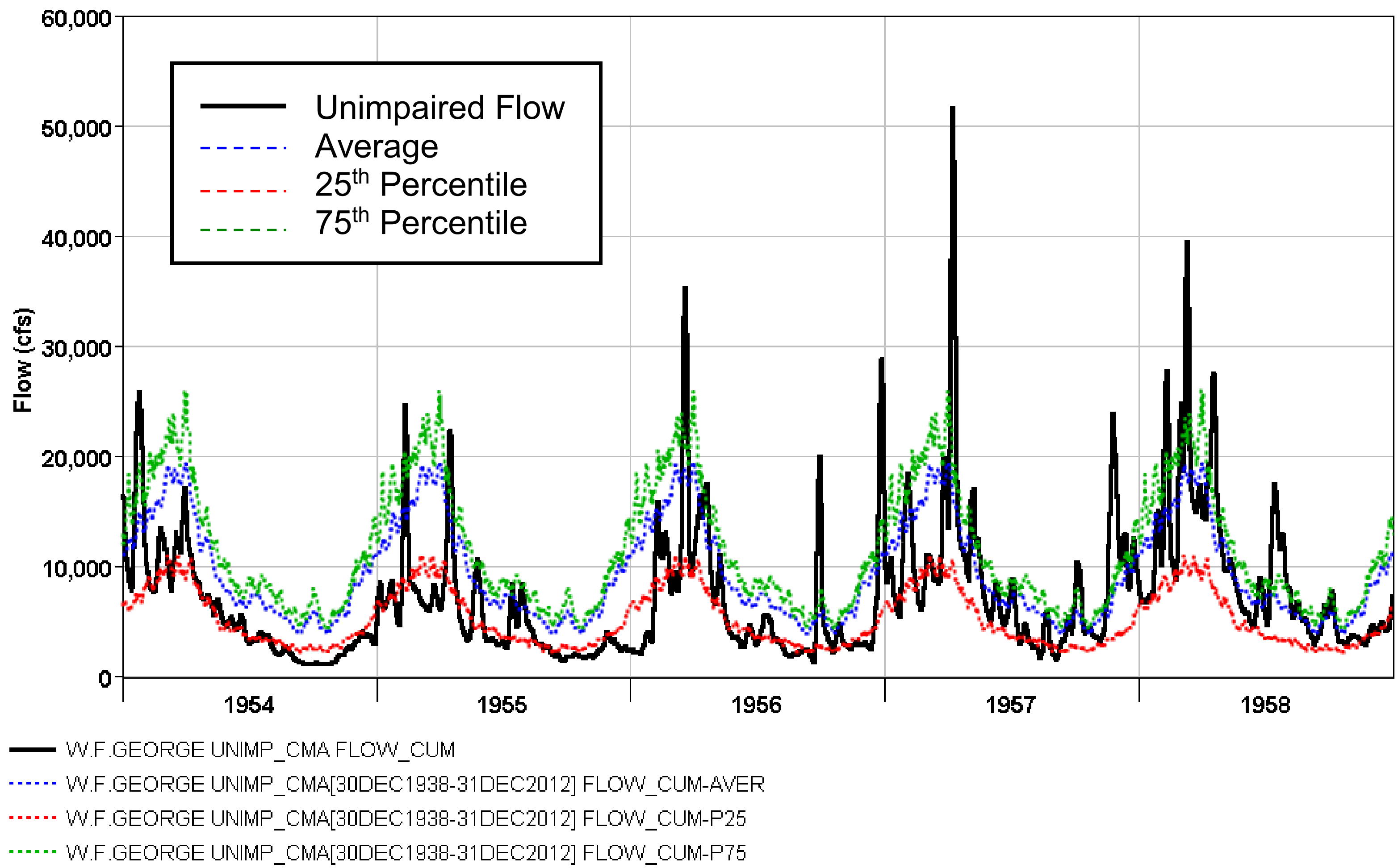


Figure B-38. Walter F. George Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

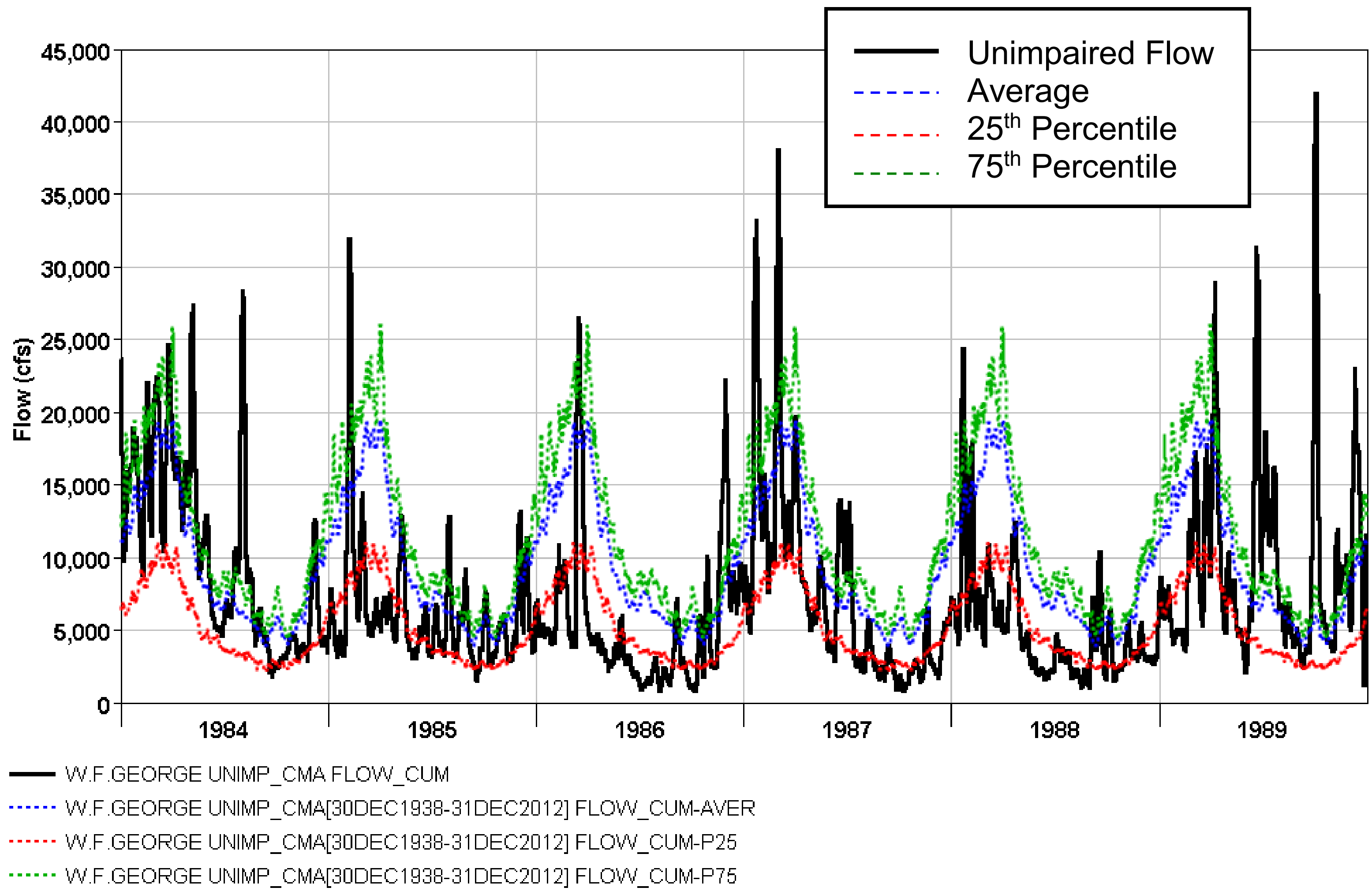


Figure B-39. Walter F. George Unimpaired Inflow – 1980's Drought; 75th Percentile, Average and 25th Percentile Flow

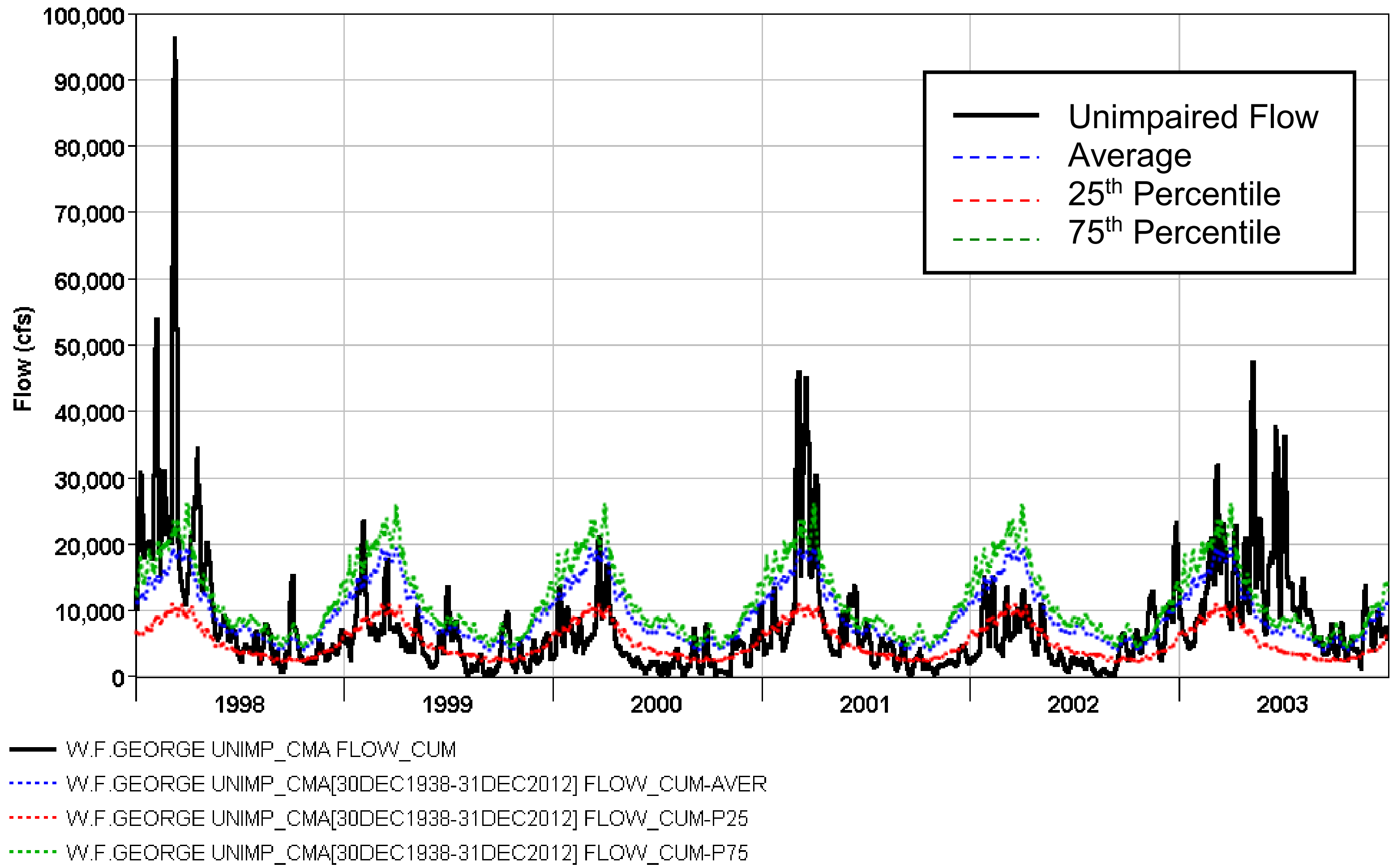


Figure B-40. Walter F. George Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

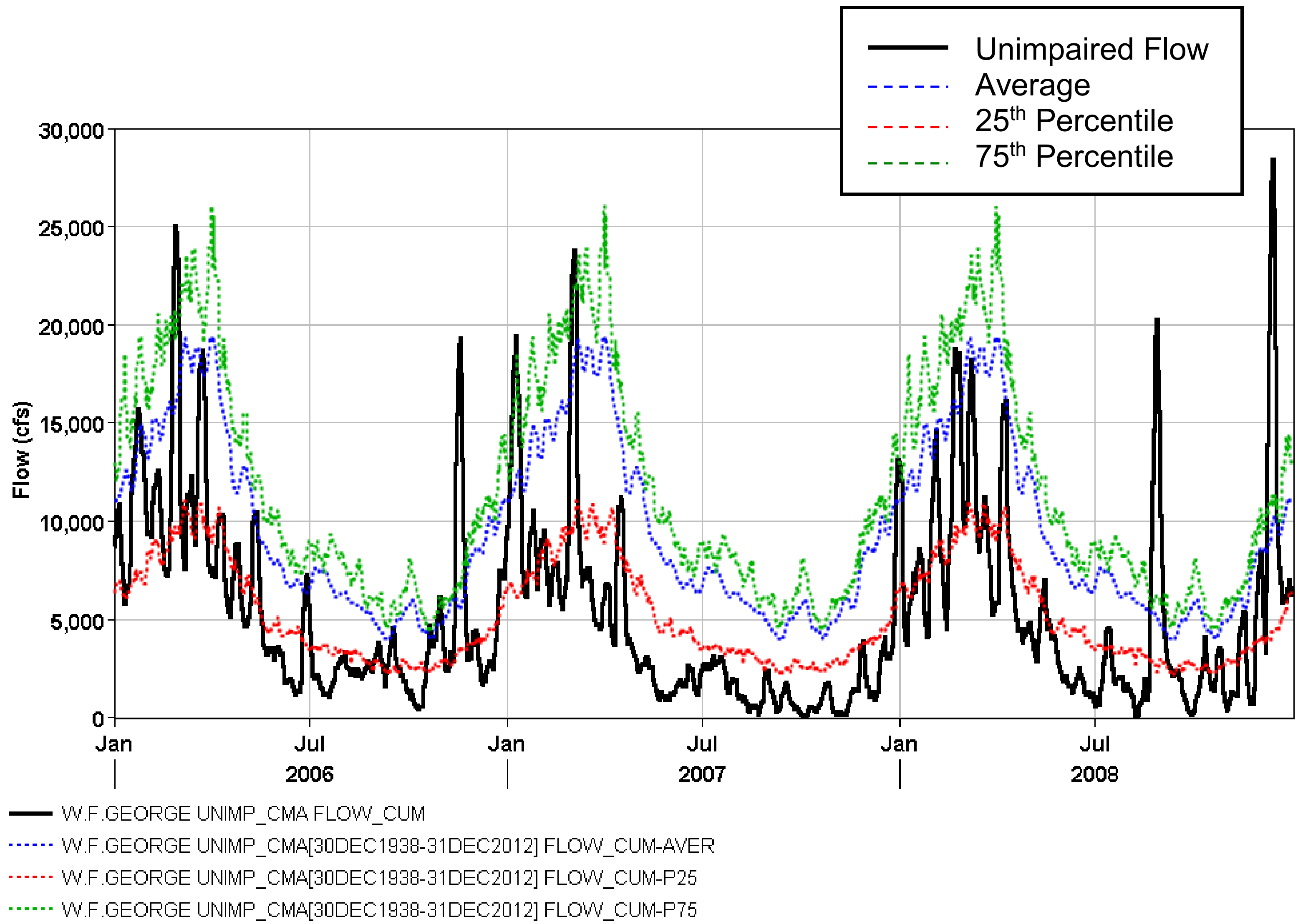


Figure B-41. Walter F. George Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

1.6 ResSim MODELING

The ResSim model for the ACF Basin is shown below in Figure B-42.

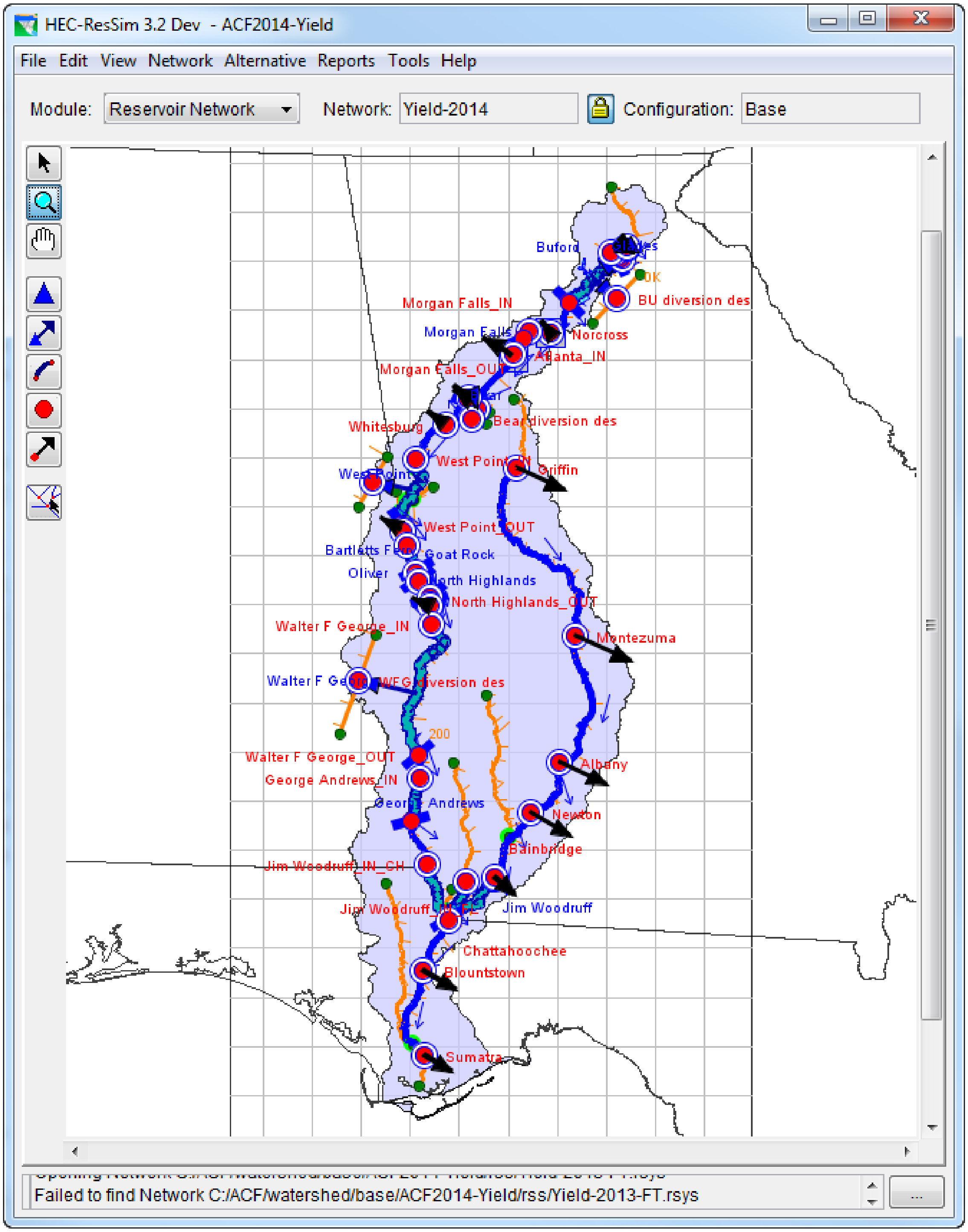


Figure B-42. ACF ResSim Model Schematic

ResSim version 3.2 Dev, December 2013 was utilized using the ResSim Watershed "ACF2014-Yield" and the network "Yield-2014". The ACF ResSim model includes five federal reservoirs, two non-federal proposed water supply reservoirs, and five non-federal hydropower projects. A variety of water supply diversions are also included. Of the total number of reservoirs in the model, two are proposed (Glades and Bear Creek) and seven are considered run-of-river (Morgan Falls, Bartlett's Ferry, Oliver, North Highlands, Goat Rock, George Andrews, and Jim Woodruff). The remaining reservoirs (Buford, West Point, and Walter F. George) are the three existing federal reservoirs considered in the yield analysis. Physical characteristics of each reservoir were incorporated into the model using the latest published reservoir regulation (water control) manual. Yield computations are dependent on the conservation storage and hydrology. The regulation plan section for each reservoir above describes the conservation storage. The ResSim operation set only includes the diverted yield rules, downstream channel capacity rules, and in the case of system yield, downstream flood control rules. Reservoir guidelines for determining releases are defined using the operation set. Method C (System Yield) also includes tandem rules in the operation set for the system yield analysis from Walter F. George.

Simulations were created for each of the five identified drought periods and the entire period of record. The length of the period was selected to capture the drawdown and refill of all projects. Buford, having the greatest amount of storage and smallest drainage area, determined the duration of the simulation period. Each yield method (A, B and C) includes one simulation for each of five drought periods and the period of record. A total of 102 simulations were run. This included 18 simulations under Method A, 66 simulations under Method B and 18 simulations under Method C (6 without diversion and 12 with diversions). Each simulation determined the yield for a particular reservoir and drought period. Simulation naming uses the drought label from Table B-8. For example, the Method A simulation name for the 1980 drought is "1980 n Div", Method B is "1980 w Div" and Method C is "Sys Yld 1980".

Table B-8. Drought Periods

Drought Periods	Label
1939-1943	1940
1954-1958	1950
1984-1989	1980
1998-2003	2000
2006-2008	2007

Method A does not include the net river withdrawals, and Method B does include the net river withdrawals and the impact of the proposed water supply projects in the yield determination. Each storage reservoir has an nDiv (no net river withdrawals) and wDiv (with net river withdrawals) alternative.

For Methods A and B, the upstream reservoir is the primary reservoir, and the yield is met first before proceeding downstream. Projects are full at the beginning of the drought period simulation. None of the yield is returned to the system. This assumes that the yield is diverted from the system and is consumptively used. This means that the yield computed at Buford was not counted as inflow to West Point or Bear Creek, downstream. This methodology determines the conservative individual project yield. As mentioned in the "Methods Employed in Critical

Yield Analysis" section, the reservoirs are operated together to compute a system yield at Walter F. George for the Method C simulations.

A diversion outlet is added to each of the three existing federal reservoirs (Buford, West Point and Walter F. George) and the two proposed non-federal reservoirs (Glades and Bear Creek). Water from the reservoir is diverted through the outlet to a location that does not flow back into the system. None of the diverted water is returned to the system. The yield represents the maximum continuous flow of water through this outlet during one of the five drought periods using all available conservation storage.

1.7 RESULTS

Table B-9 presents the results from each of the simulations for Method A. The pool elevations and yield flow values are presented graphically in Figures B-43 – B-45. The flow represents the total release from the reservoir. When the flow hydrograph rises above the constant yield value, flows are released through the reservoir.

Table B-9. Yield Analysis without River Diversions, Method A

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Period**
Lanier	1769	1791	1459	1511	1619	1980
West Point	1711	1206	1427	1225	809	2007
Walter F. George	2165	1620	1393	870	575	2007

Method A critical yield for Buford is 1,459 cfs and the critical period is the 1980 drought period
Method A critical yield for West Point is 809 cfs and the critical period is the 2007 drought period
Method A critical yield for Walter F. George is 575 cfs and the critical period is the 2007 drought period

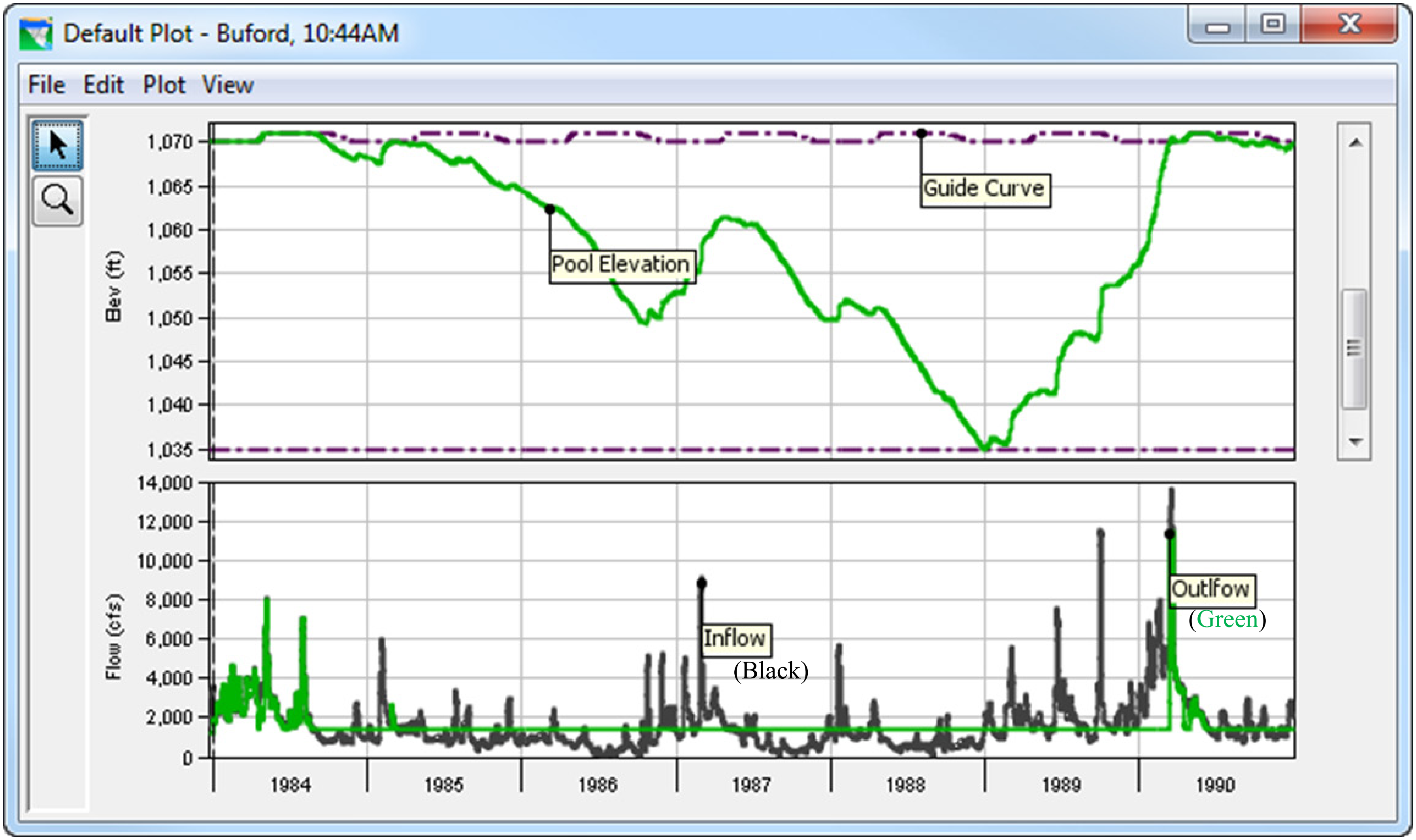


Figure B-43. Buford Critical Yield Result, Method A (No Diversions)

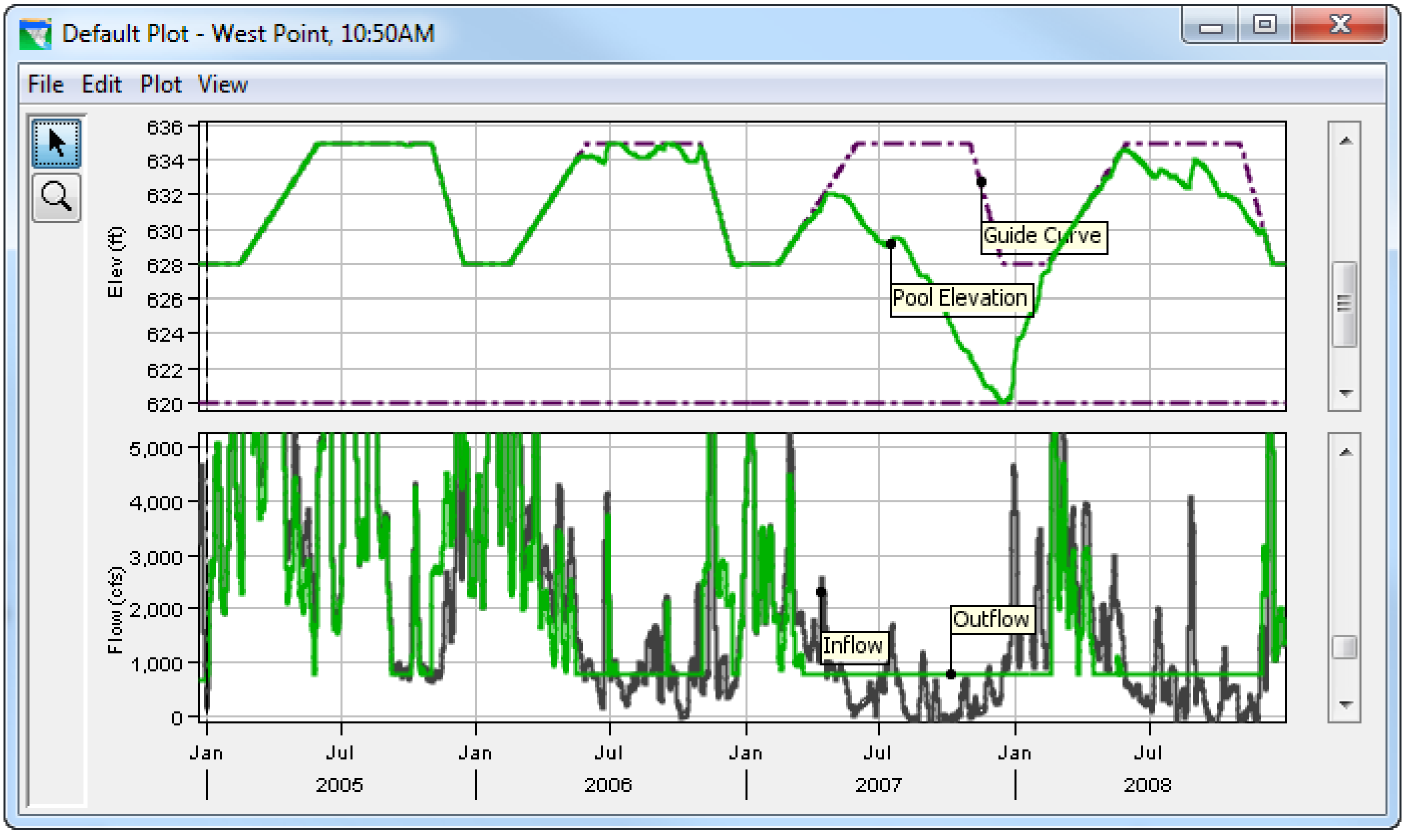


Figure B-44. West Point Critical Yield Result, Method A (No Diversions)

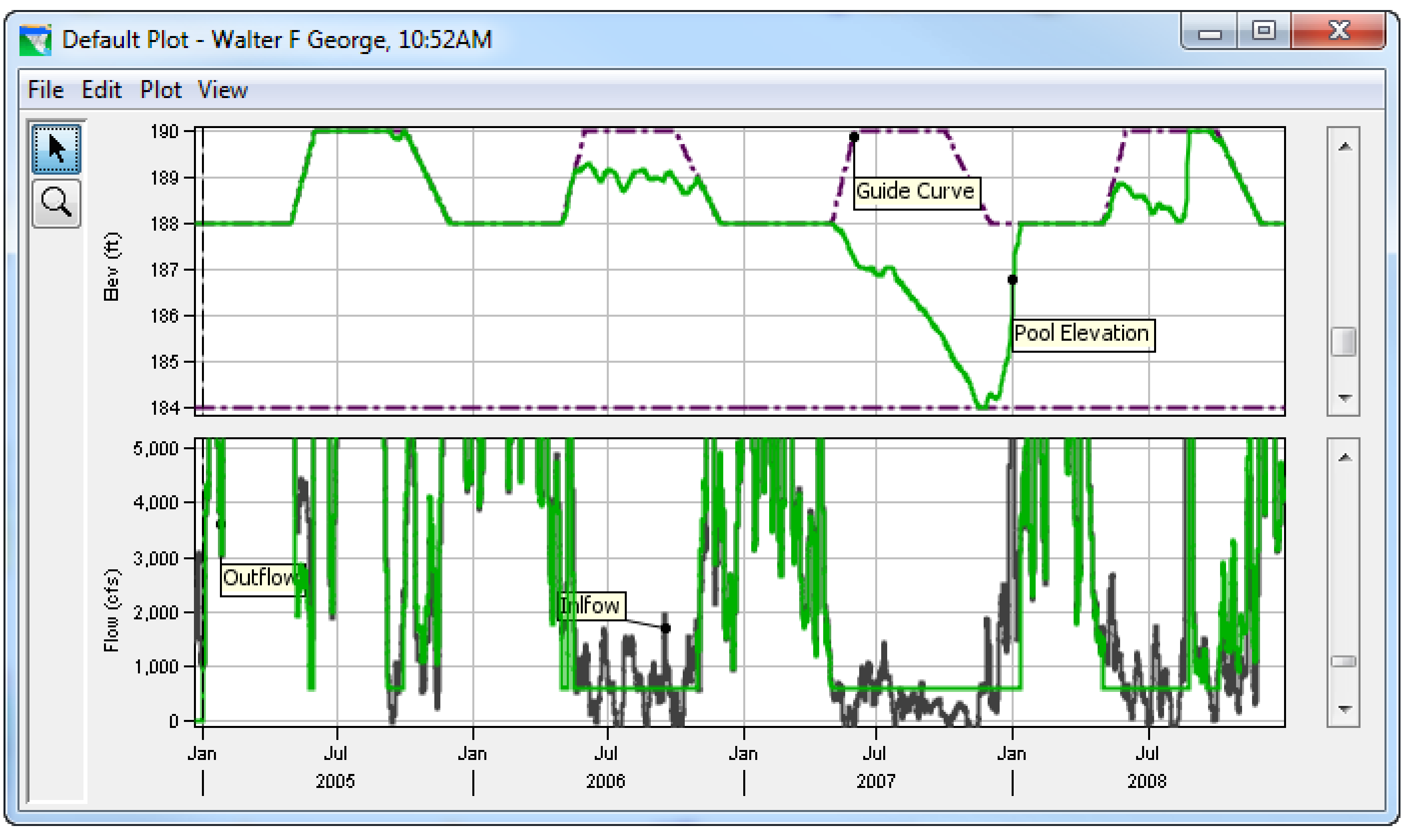


Figure B-45. Walter F. George Critical Yield Result, Method A (No Diversions)

The drawdown period for each drought period is listed in Table B-10.

Table B-10. ACF Yield Drawdown Period

Drought Label	Buford	West Point	Walter F. George
1940	Jun 1939 - Feb 1946	Apr 1941 - Jan 1942	May 1941 - Dec 1941
1950	Apr 1954 - Apr 1962	May 1954 - Feb 1955	May 1954 - Feb 1955
1980	Mar 1985 - Mar 1990	Mar 1986 - Dec 1986	May 1986 - Nov 1986
2000	Jun 1998 - Sep 2004	Apr 2000 - Feb 2001	Apr 2000 - Dec 2000
2007	Mar 2006 – Dec 7 2008	Mar 2007 - Feb 2008	Apr 2007 - Jan 2008

Table B-11 below captures the impact of net year 2007 river withdrawals above the lakes from the Chattahoochee River and tributaries. Graphical results of the pool elevation and yield are presented in Figures B-46, B-47, and B-48. The yield at Buford is reduced by 4.5% due to operations that ensure flow for downstream river withdrawals. However, a large portion of these river withdrawals are returned as treated water to the river upstream of West Point. As a result, the critical yield at West Point given upstream river diversions is 18% greater than the yield when there are no diversions

Table B-11. Yield Analysis with River Diversions, Method B, Glades & Bear Creek Flow Thru

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Period**
Buford	1590	1561	1393	1399	1450	1980
West Point	1828	1389	1451	1319	959	2007
Walter F. George	2219	1637	1292	780	477	2007

Method B critical yield for Buford is 1,393 cfs and the critical period is the 1980 drought period
Method B yield for West Point is 959 cfs and the critical period is the 2007 drought period
Method B yield for Walter F. George is 477 cfs and the critical period is the 2007 drought period

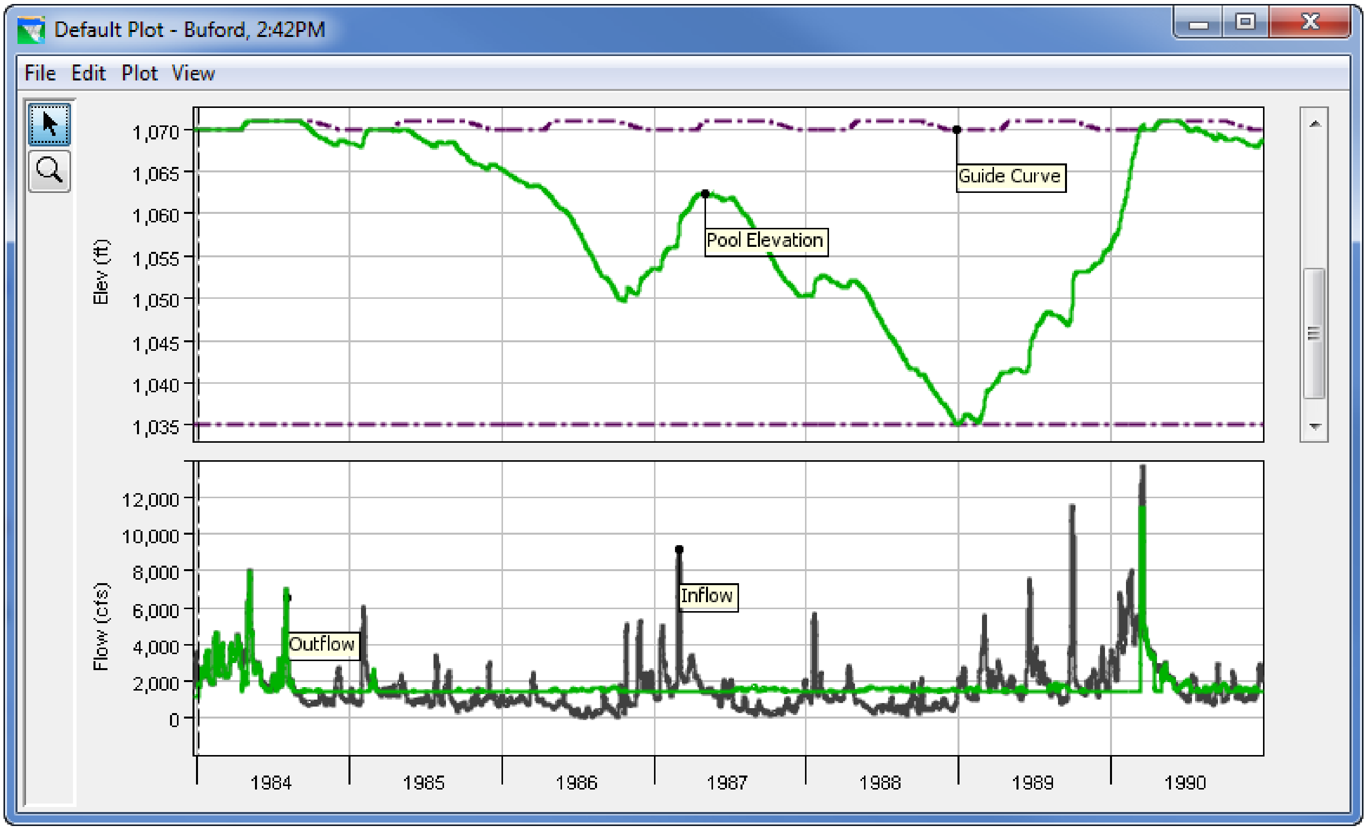


Figure B-46. Buford Critical Yield Result, Method B (With Diversions)

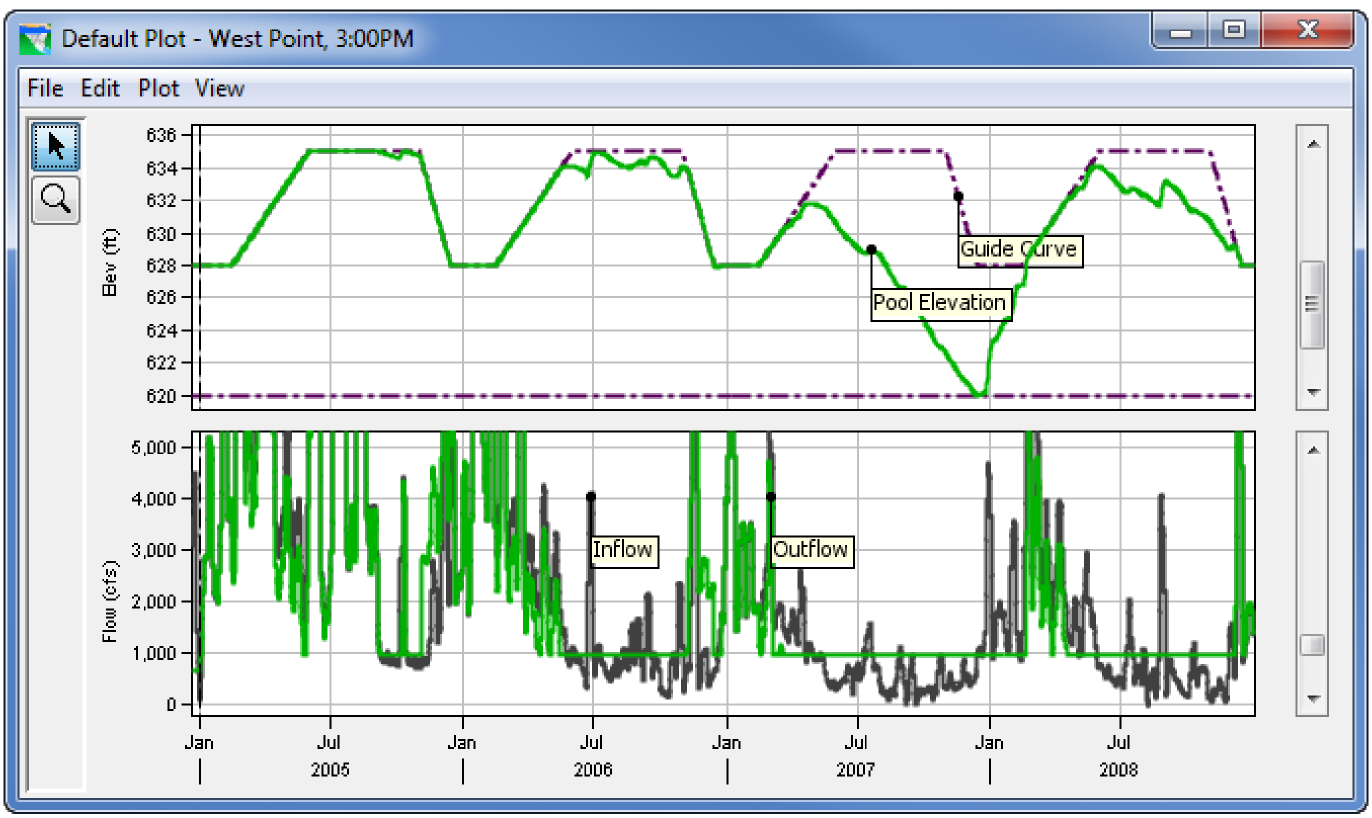


Figure B-47. West Point Critical Yield Result, Method B (With Diversions)

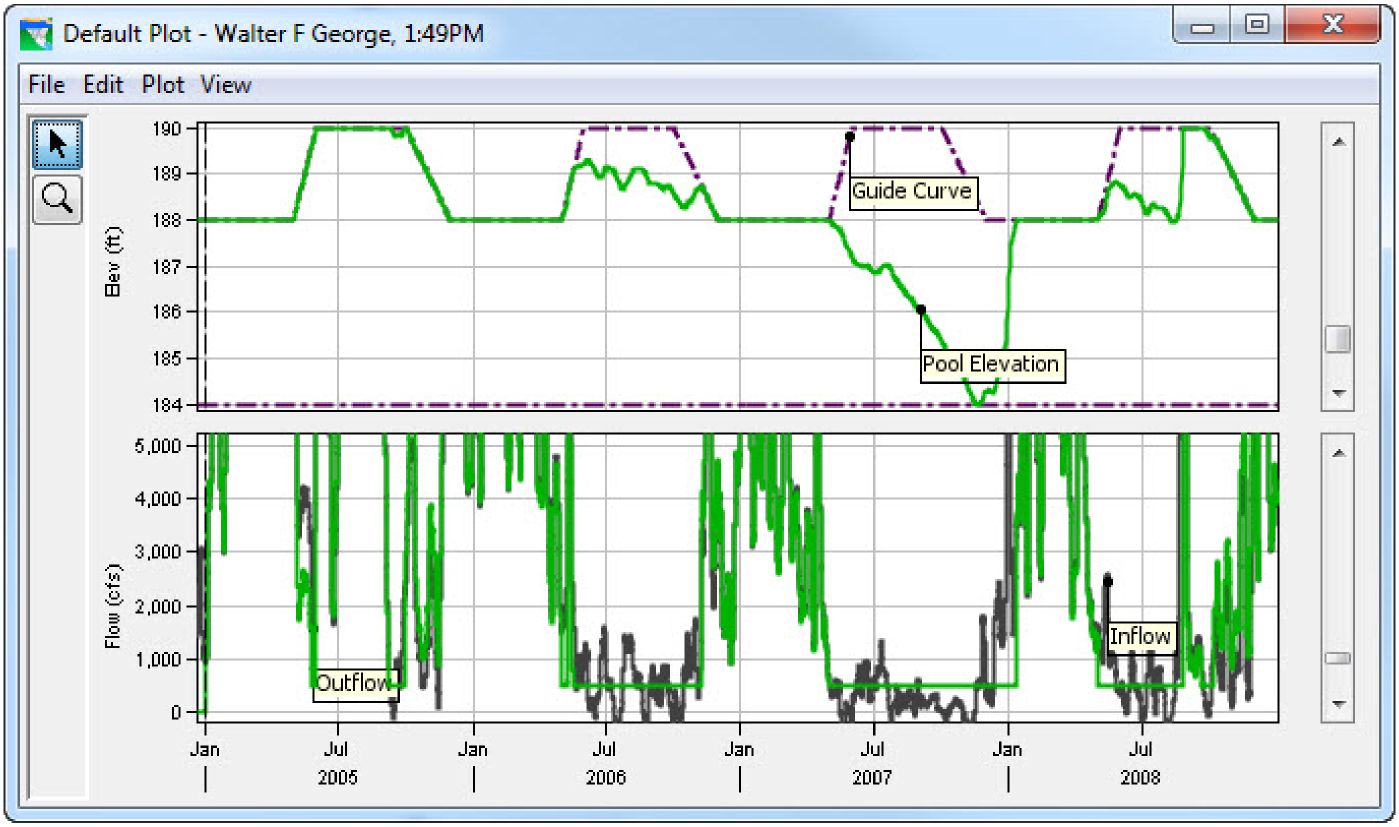


Figure B-48. Walter F. George Critical Yield Result, Method B (With Diversions)

Table B-12 below illustrates the impact of river withdrawals and the diverted yield of the proposed Glades and Bear Creek Reservoirs. Graphical results of the pool elevation and yield are presented in Figures B-49 through B-53. Yield values are less than those in Table B-11 for Buford and West Point because the inflow into the existing reservoirs is reduced by the diverted yield from the proposed reservoirs (Glades and Bear Creek). The critical yield reduction from the no diversions method for Buford is 8.9%. The critical yield actually increases by 18% at West Point due to the nature of river withdrawals and returns above the reservoir.

Table B-12. Yield Analysis with River Diversions, Method B, Glades & Bear Creek Yield Out

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Period**
Glades	78	80	75	76	72	2007
Buford	1523	1491	1329	1332	1393	1980
Bear Creek	27	18	21	21	16	2007
West Point	1821	1383	1446	1316	956	2007
Walter F. George	2177	1636	1292	780	477	2007

Method B critical yield for Glades is 72 cfs and the critical period is the 2007 drought period
Method B critical yield for Buford is 1329 cfs and the critical period is the 1980 drought period
Method B critical yield for Bear Creek is 16 cfs and the critical period is the 2007 drought period
Method B l yield for West Point is 956 cfs and the critical period is the 2007 drought period
Method B yield for Walter F. George is 477 cfs and the critical period is the 2007 drought period

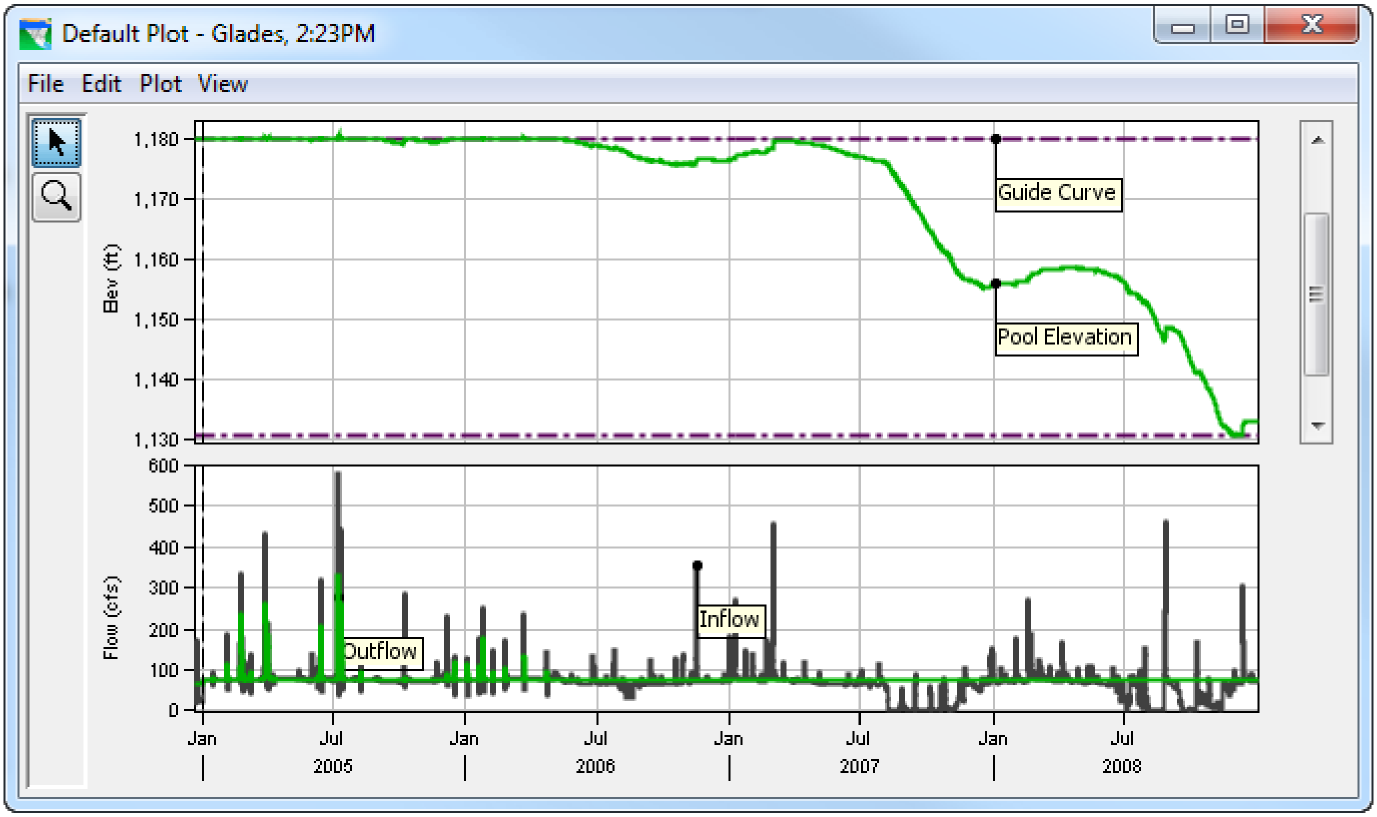


Figure B-49. Glades Critical Yield Result, Method B (With Diversions)

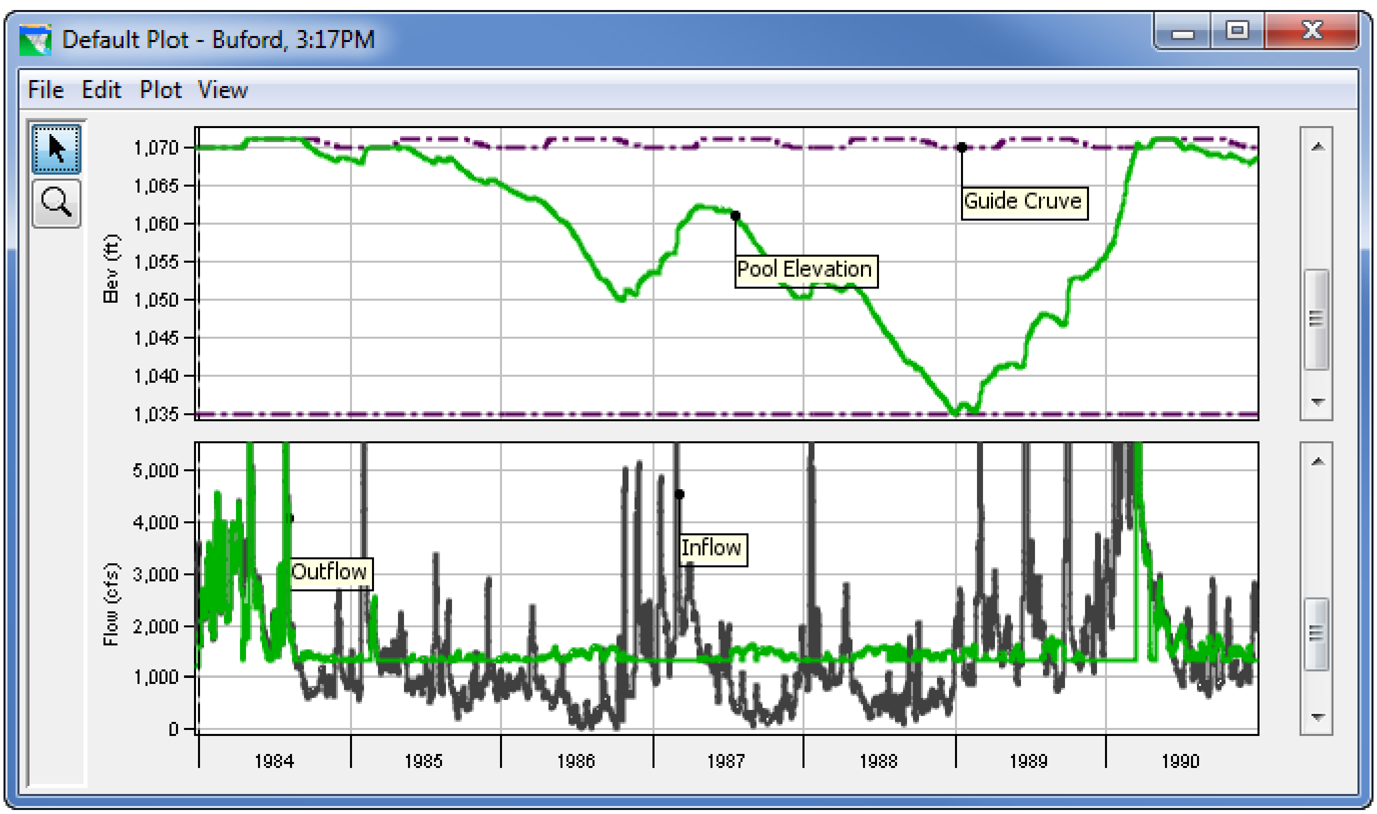


Figure B-50. Buford Critical Yield Result, Method B (With Diversions, Glades Diverted)

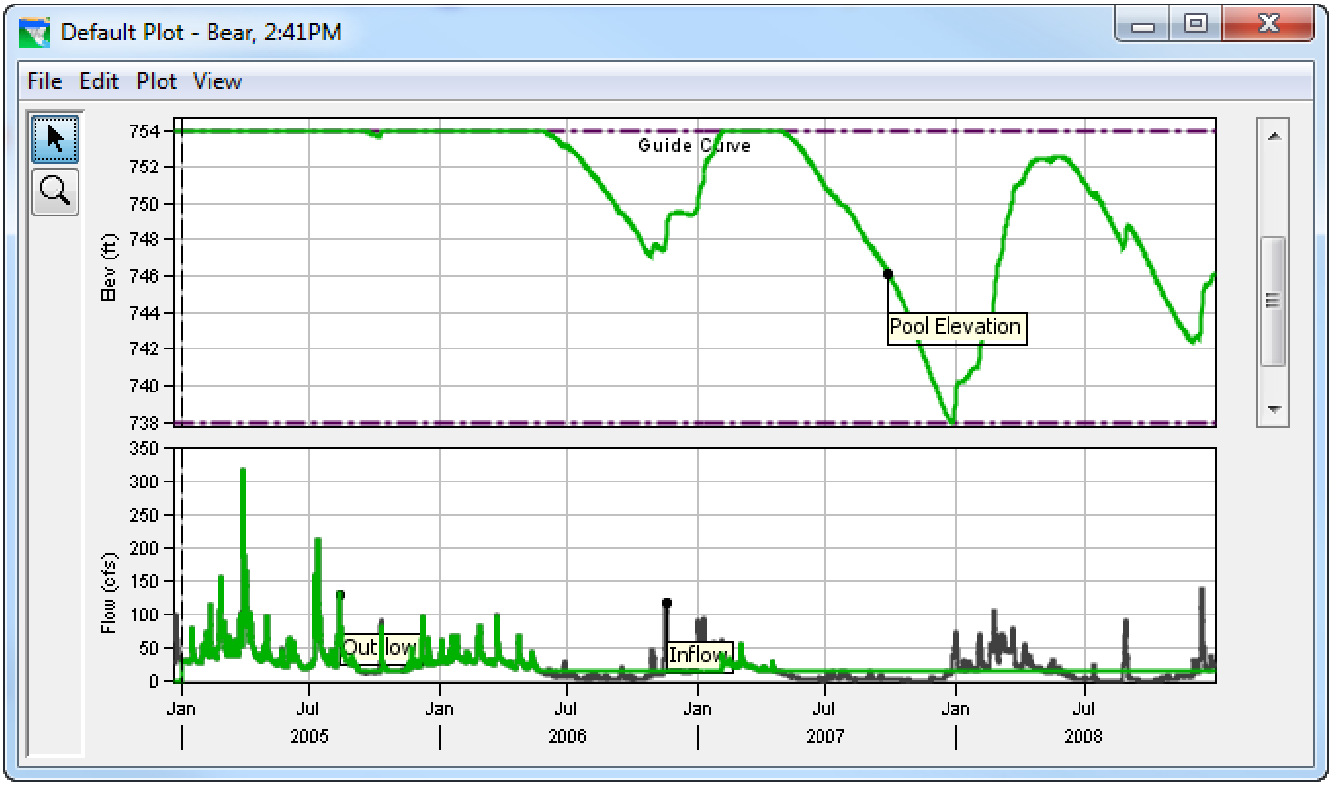


Figure B-51. Bear Creek Critical Yield Result, Method B (With Diversions, Glades Diverted)

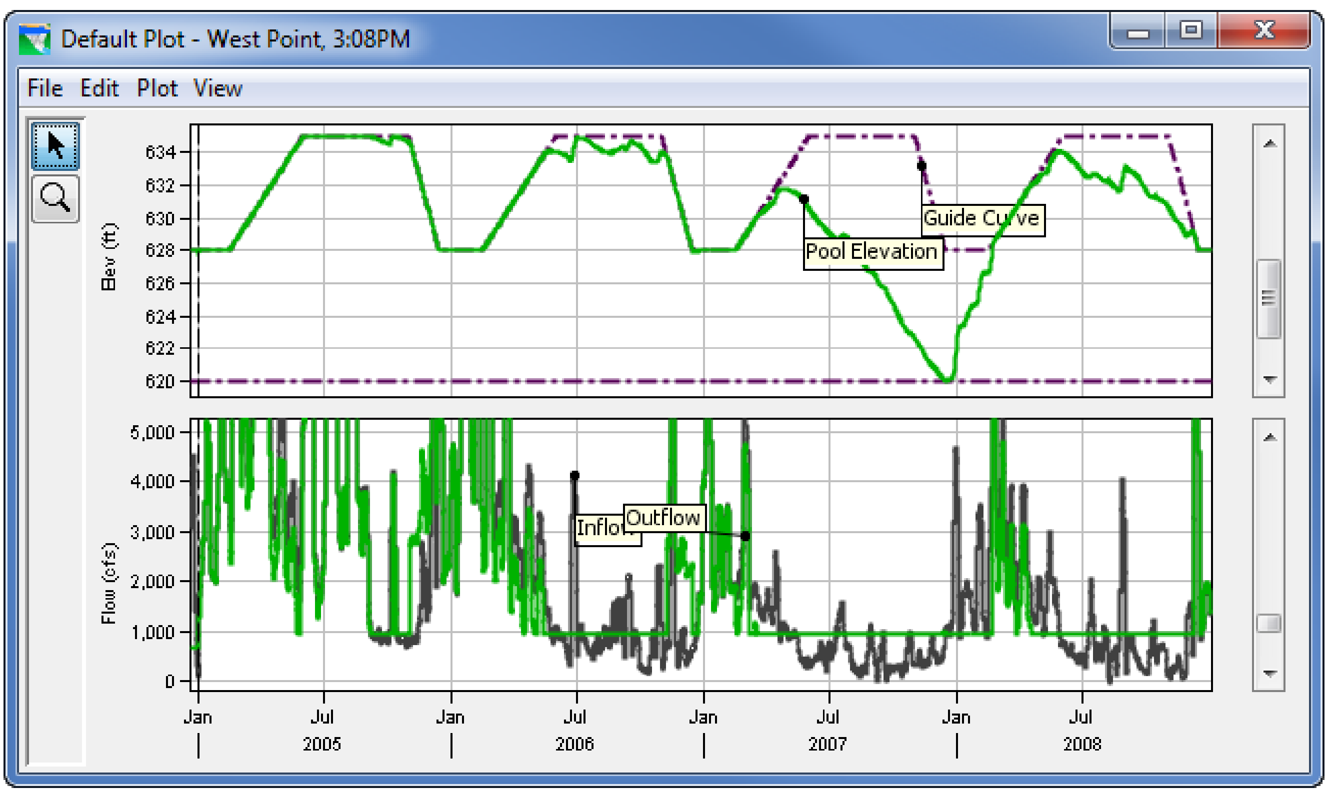


Figure B-52. West Point Critical Yield, Method B (w/Div, Glades & Bear Creek Diverted Out)

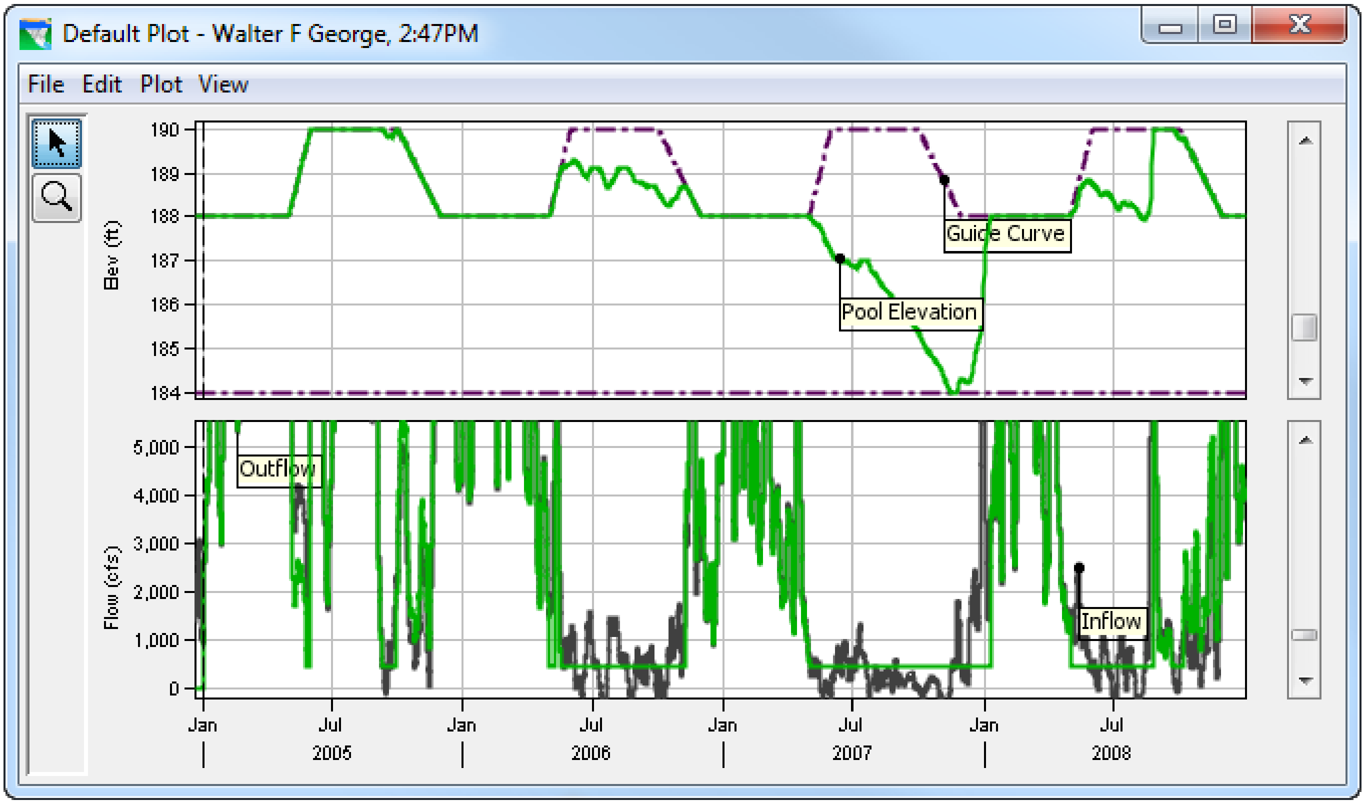


Figure B-53. WFG Critical Yield Result, Method B (w/Div, Glades & Bear Creek Diverted Out)

Table B-13 below shows the yield at Buford assuming river withdrawals but not operating to completely fulfill those withdrawals. Buford yield values are greater than values in Tables B-11 and B-12 because Lake Lanier is not operating to provide flow for downstream diversions. This table also illustrates two proposed operations for Glades reservoir and their impact on Buford Yield: diverting Glades yield out of the system and diverting (releasing) Glades yield directly to Lake Lanier. The critical yield increases when diverting (releasing) Glades yield back to Lake Lanier by 0.6% versus when Glades is a flow thru reservoir. There is a 4.4% reduction in Buford yield when diverting Glades yield out of the system rather than operating Glades as a flow thru reservoir. Graphical results of the pool elevation and yield are presented in Figures B-54 through B-56.

Table B-13. Buford Yield Analysis with River Diversions, Method B, No Downstream Control Operations

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Period**
Glades Flow Thru	1762	1785	1452	1504	1612	1980
Glades Diverting Out	1696	1712	1388	1437	1555	1980
Glades Releasing to Lake Lanier	1768	1785	1460	1510	1627	1980

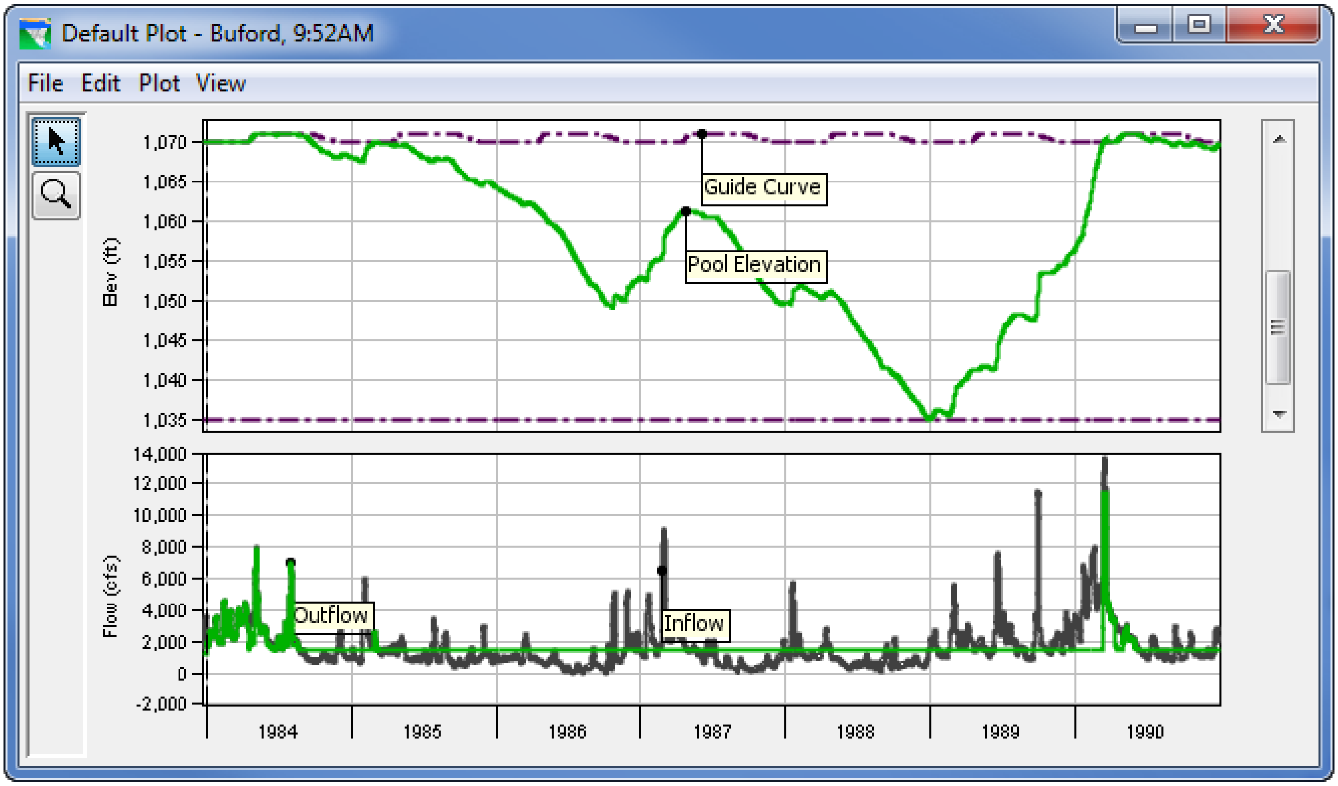


Figure B-54. Buford Critical Yield Result, Method B (w/Div, Glades Flow Thru)

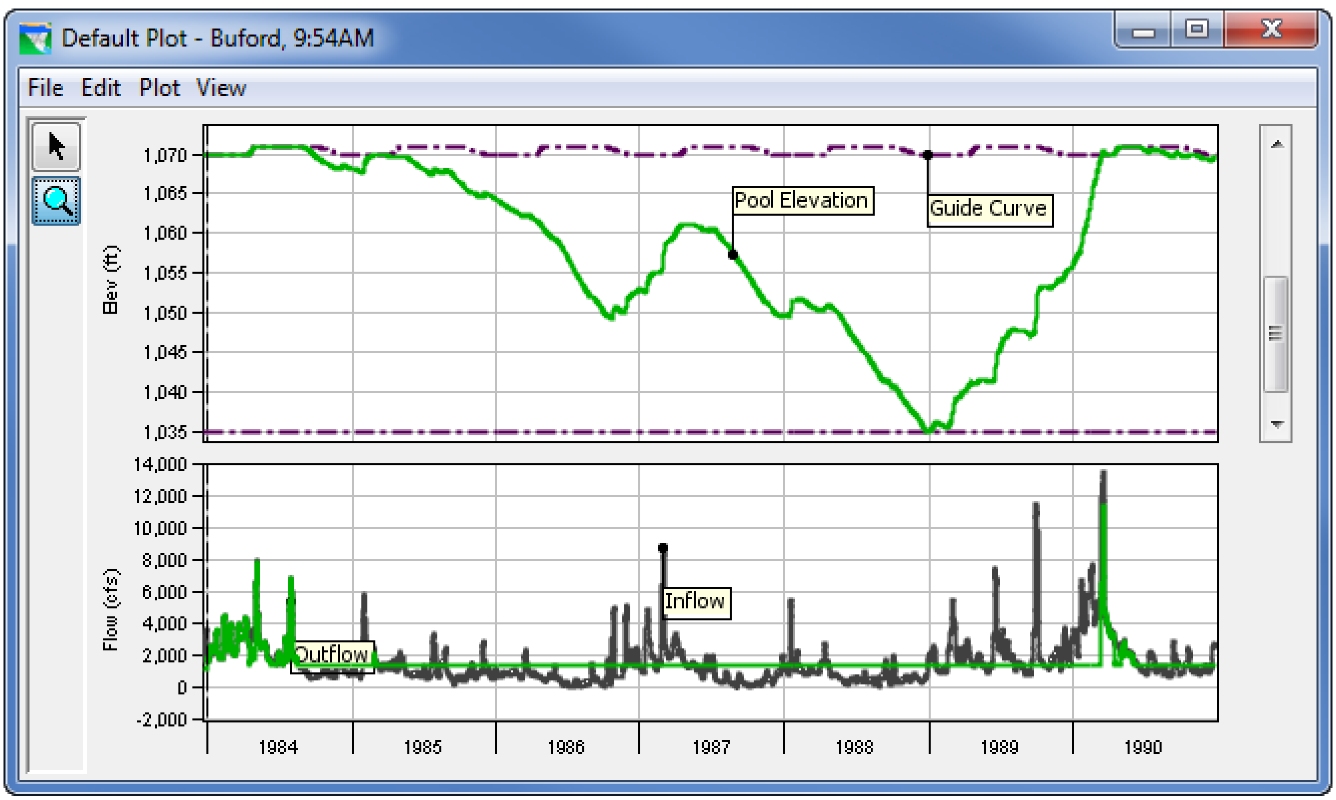


Figure B-55. Buford Critical Yield Result, Method B (w/Div, Glades Diverting Out)

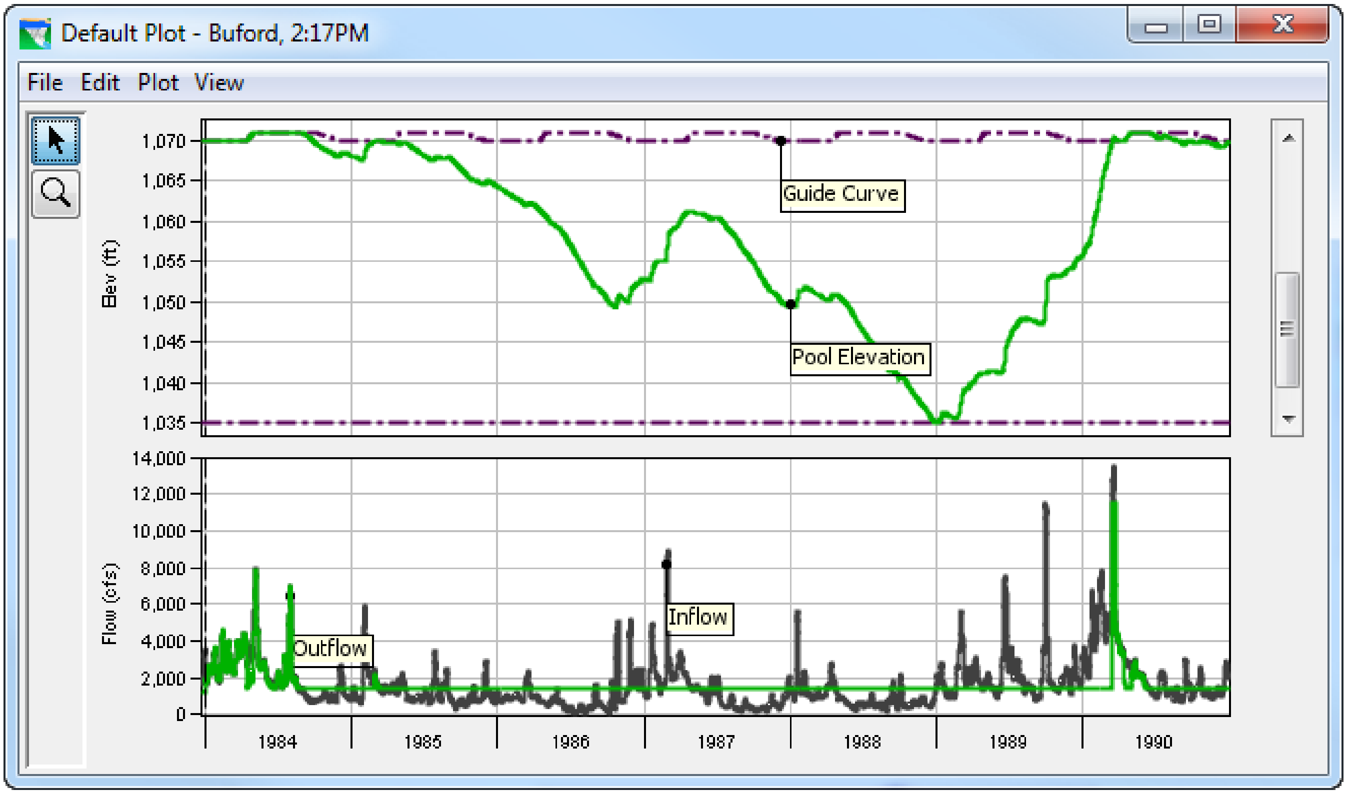


Figure B-56. Buford Critical Yield Result, Method B (w/Div, Glades Diverting Back)

Table B-14 presents the results from ACF system analysis, Method C. The table shows that, using the 2007 river diversions, the system yield is reduced 3.9%, from 4110 cfs to 3948 cfs. When the proposed Glades and Bear Creek reservoirs are allowed to divert out critical yield, the system yield is reduced further by 1.7%. Graphical results are presented in Figures B-57 through B-59.

Table B-14. ACF System Yield Analysis, Method C

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Period**
System without Diversions	6059	5098	5141	4581	4110	2007
System with Diversions	5907	4934	4975	4408	3948	2007
SysWDiv, Glades and Bear Creek yield diverted out	5821	4842	4872	4297	3881	2007

Figure B-57. System Critical Yield Result, Method C (No Diversions)

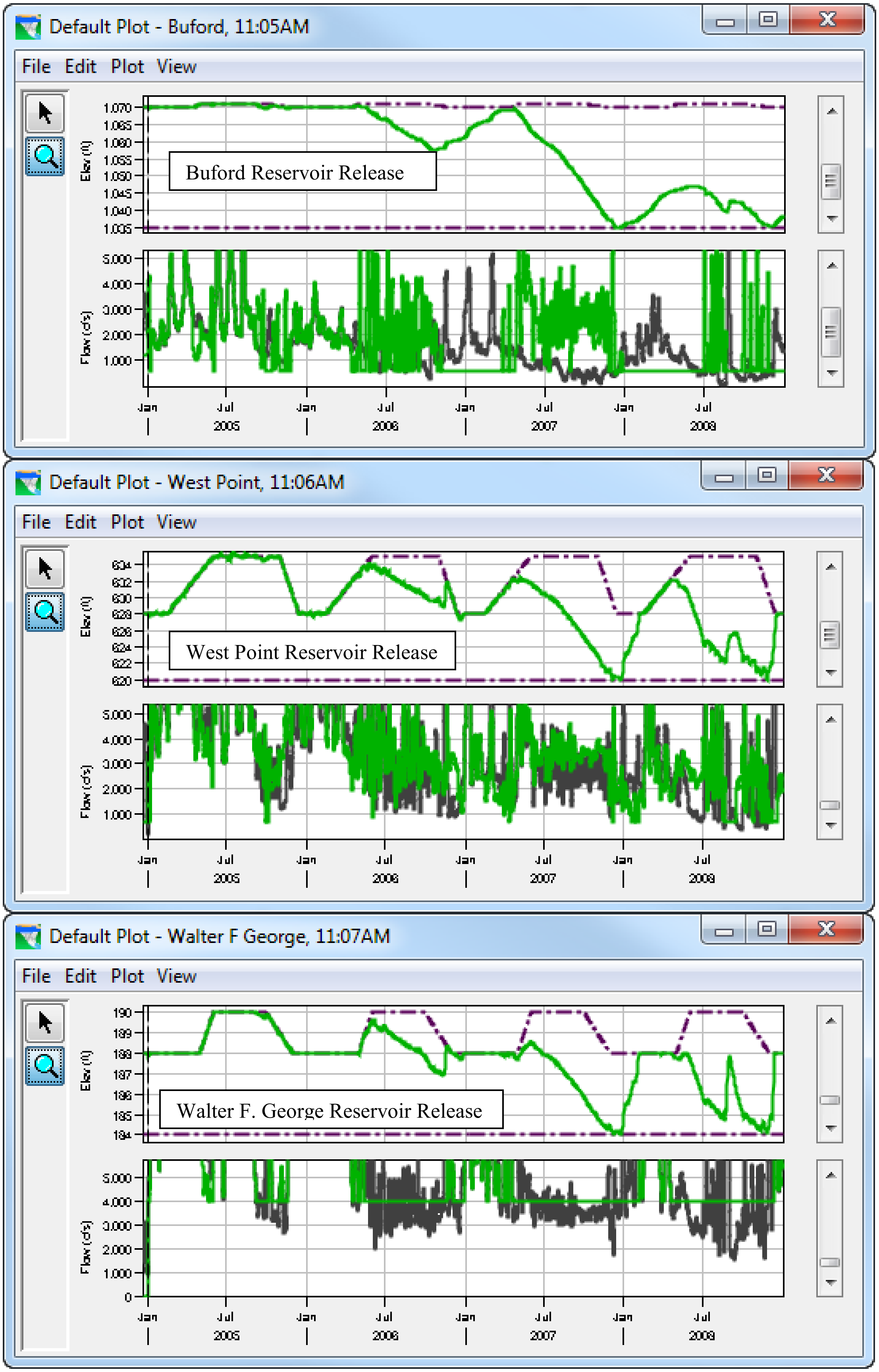
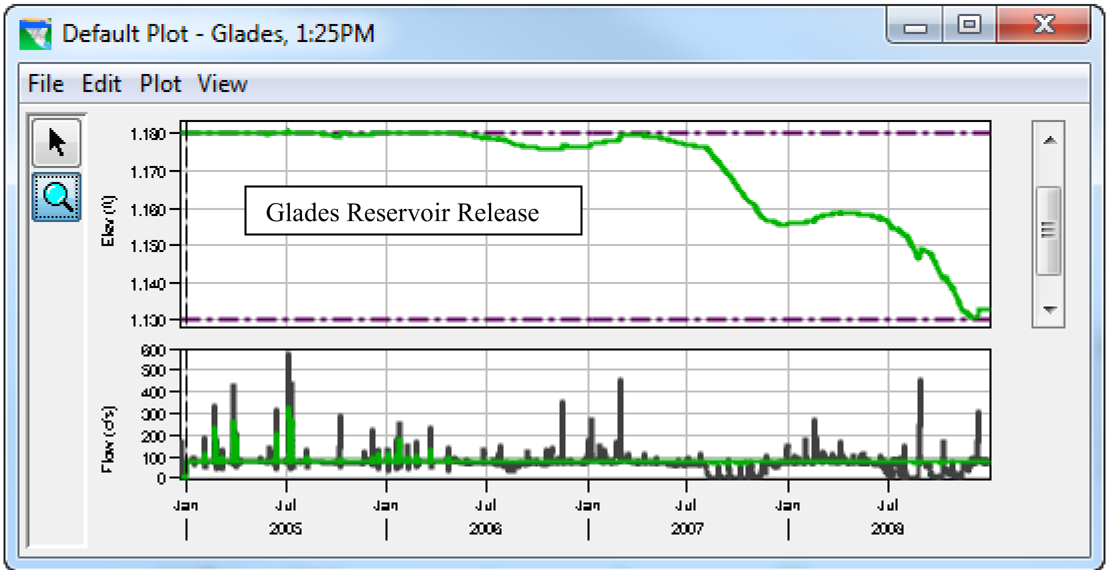
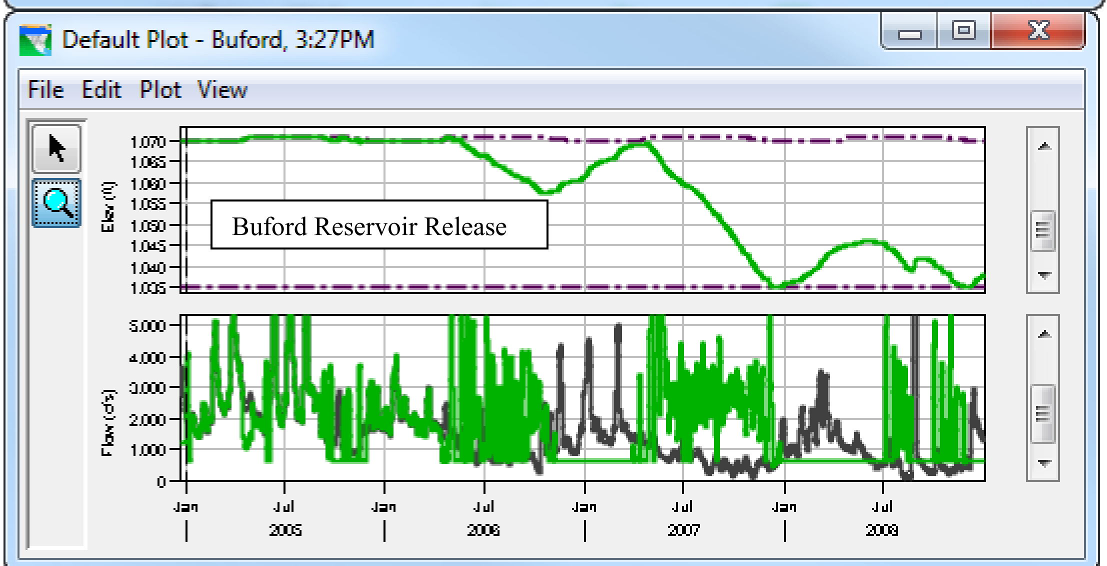
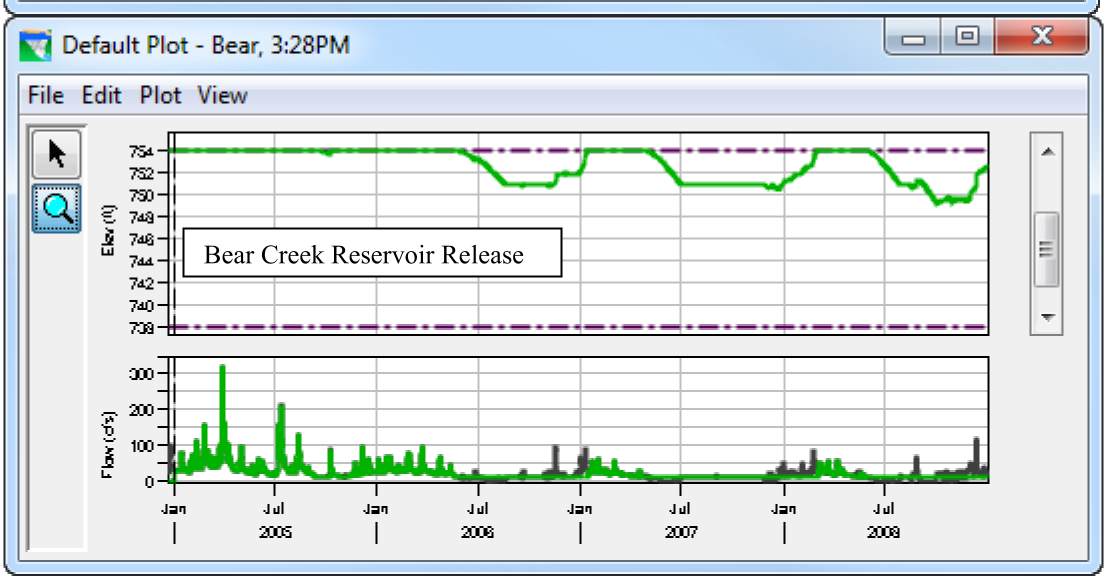


Figure B-58. System Critical Yield Result, Method C (With Diversions)


Default Plot - Glades, 1:25PM
File Edit Plot View
Glades Reservoir Release
Elev (ft)
1,190
1,180
1,170
1,160
1,150
1,140
1,130
Flow (cfs)
600
500
400
300
200
100
0
Jan
Jul
2005
Jan
Jul
2006
Jan
Jul
2007
Jan
Jul
2008


Default Plot - Buford, 3:27PM
File Edit Plot View
Buford Reservoir Release
Elev (ft)
1,070
1,065
1,060
1,055
1,050
1,045
1,040
1,035
Flow (cfs)
5,000
4,000
3,000
2,000
1,000
0
Jan
Jul
2005
Jan
Jul
2006
Jan
Jul
2007
Jan
Jul
2008


Default Plot - Bear, 3:28PM
File Edit Plot View
Bear Creek Reservoir Release
Elev (ft)
754
752
750
748
746
744
742
740
738
Flow (cfs)
300
200
100
0
Jan
Jul
2005
Jan
Jul
2006
Jan
Jul
2007
Jan
Jul
2008

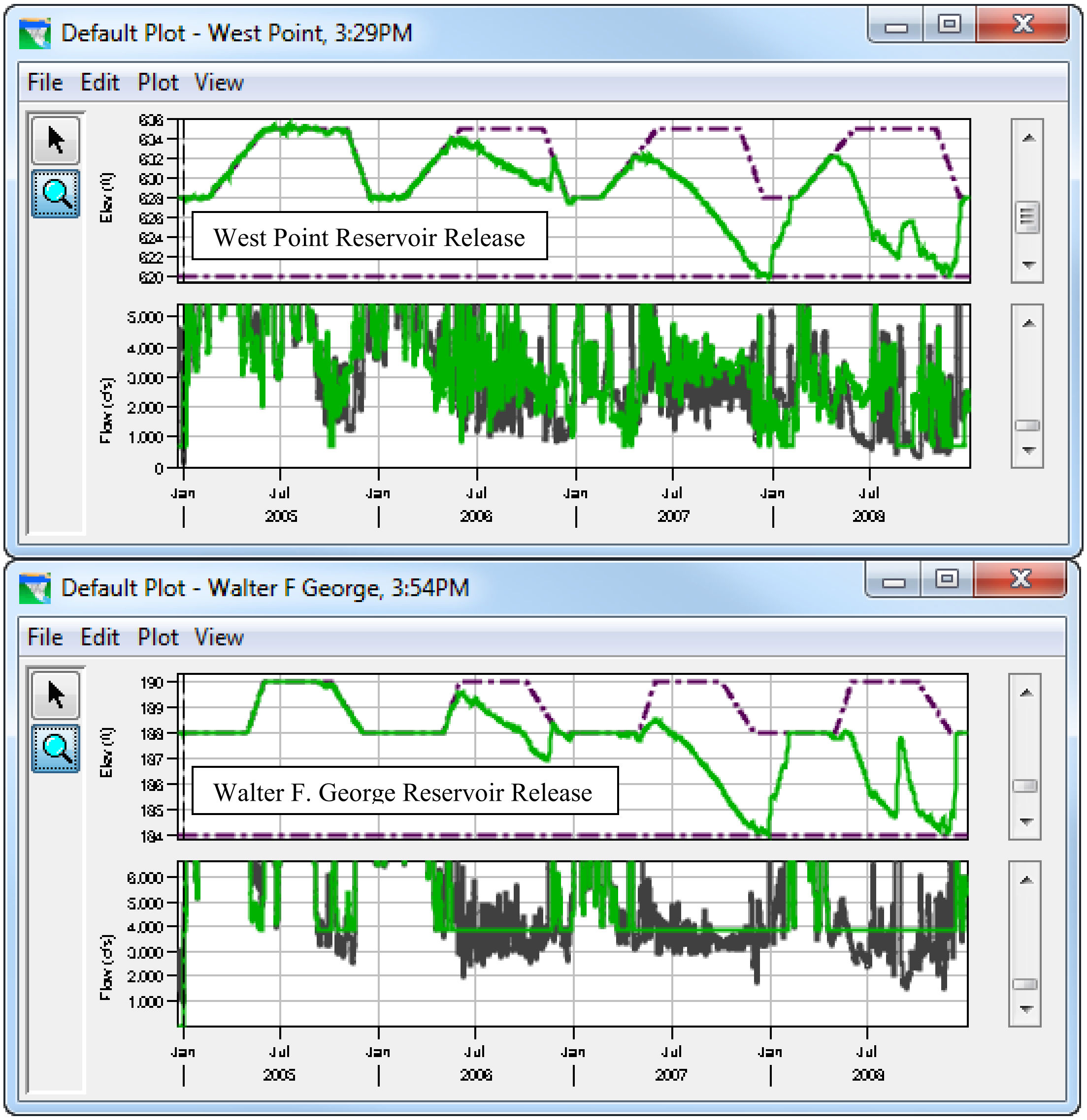


Figure B-59. System Critical Yield Result, Method C (With Diversions, Glades and Bear Yield Diverted Out)

Appendix C

Prior Reports and References

1 PRIOR REPORTS AND REFERENCES

The Corps has calculated and published critical yield for the ACF federal projects many times throughout project lifespans. Yield values have been updated as more observed hydrologic data has become available. This information can be used to determine the severity of droughts throughout the period of record.

Reports printed prior to 1980 may employ the term prime flow. Prime flow, when used in these reports, is synonymous with critical yield or firm yield.

Table C-1. Prior Reports

Project	Critical Yield (cfs)	Critical Period	Source	Conservation Storage Pool (Elevation-Feet)	Conservation Storage (ac-ft)	Winter/ Summer Pool
Buford	1,600	Sep 1939-Nov 1942	1949, Buford Defined Report, Volume1	1065-1030	Unavailable	Unavailable
Buford	1,634	Unavailable	1947 House Document 300	1065-1025	1,033,000	Unavailable
Buford	1,600	Unavailable	1960, Cost Allocation Studies Report, (May 1959; revised 27 Oct 1960)	1070-1035	1,049,000	Unavailable
Buford	1,714	1939-42	1989 Lake Lanier Reregulation Dam Design Memorandum, Supplement No. 1	1070-1035	1,049,000	Unavailable
Buford	1,734 1,455*	1939-42 1980's	1989, Post Authorization Change Notification Report For The Reallocation of Storage from Hydropower to Water Supply at Lake Lanier, GA	1070-1035	1,049,000	Unavailable
Buford	1,600 1,485	1939-1942 1986-1988	1999, Letter form Mobile District to Federal Commissioner, ACT/ACF River Basins Commission	1070-1035	1,049,000	Unavailable
Buford	1,487	1985-1989	2003, Southeast Federal Power Customers Settlement Agreement	1070-1035	1,049,000	Unavailable

Table C-1 (Cont'd). Prior Reports

Project	Critical Yield (cfs)	Critical Period	Source	Conservation Storage Pool (Elevation-Feet)	Conservation Storage (ac-ft)	Winter/ Summer Pool
Buford	1,465#/ 1,460##	1980's	2010, Federal Storage Reservoir Critical Yield Analyses	1,070 (Winter) 1,071 (Summer)	1,049,400 (Winter) 1,086,600 (Summer)	1,070/1,071
West Point	2,570**	1950	1962, West Point Project Authority, House Document 570, 87th Congress	635-620 (Winter) 625-620 (Summer)	284,000 (Winter) 78,000 (Summer)	635/625
West Point	1,167#/ 891##	2007	2010, Federal Storage Reservoir Critical Yield Analyses	628 (Winter) 635 (Summer)	442,016 (Winter) 604,516 (Summer)	628/635
W. F. George	6,750**	Unavailable	1960, Cost Allocation Studies Report (May 1959; Revised 27 Oct 1960)	190-184	Unavailable	185/190
W. F. George	572#/ 470##	2007	2010, Federal Storage Reservoir Critical Yield Analyses	188 (Winter) 190 (Summer)	847,100 (Winter) 934,400 (Summer)	188/190

*This represents a preliminary critical yield value that was calculated before the 1980's drought ended.
**Yield based on system analysis similar to Method C.
#Method A
##Method B

Appendix D

Drought Description

1 DROUGHT DESCRIPTIONS

Five major, long-term (3 or more years) drought episodes have been identified during the period of record for the ACF and ACT River Basins in Alabama and Georgia. Each of these drought episodes displays differing spatial and temporal characteristics.

1.1 2006-2008

The 2006-08 drought was by far the most devastating drought recorded in Alabama and western Georgia. Precipitation declines began in December, 2005. These shortfalls continued through Winter 2006-07 and Spring 2007, exhibiting the driest winter and spring in the period of record. The drought reached peak intensity in 2007, resulting in a D-4 Exceptional Drought Intensity (the worst measured) throughout the Summer, 2007. Lakes and reservoirs dropped to the lowest levels ever recorded. Rainfall at Gainesville, Georgia (Lake Lanier) was only 20 inches for the entire year.

1.2 1998-2003

This period initiated the most recent multi-year drought "cycle". The drought reached peak severity in Summer, 2000, accompanied by all-time record high temperatures in many areas.

1.3 1984-1989

In the extreme northern portions of the ACF and ACT Basins, the 1984-89 drought was the worst drought known until that time. Precipitation from December 1985 through July 1986 was less than 40 percent of normal. Birmingham, Alabama and Chattanooga, Tennessee received only 17 inches of precipitation. The drought climaxed in July 1986, exacerbated by extremely high temperatures.

1.4 1954-1958

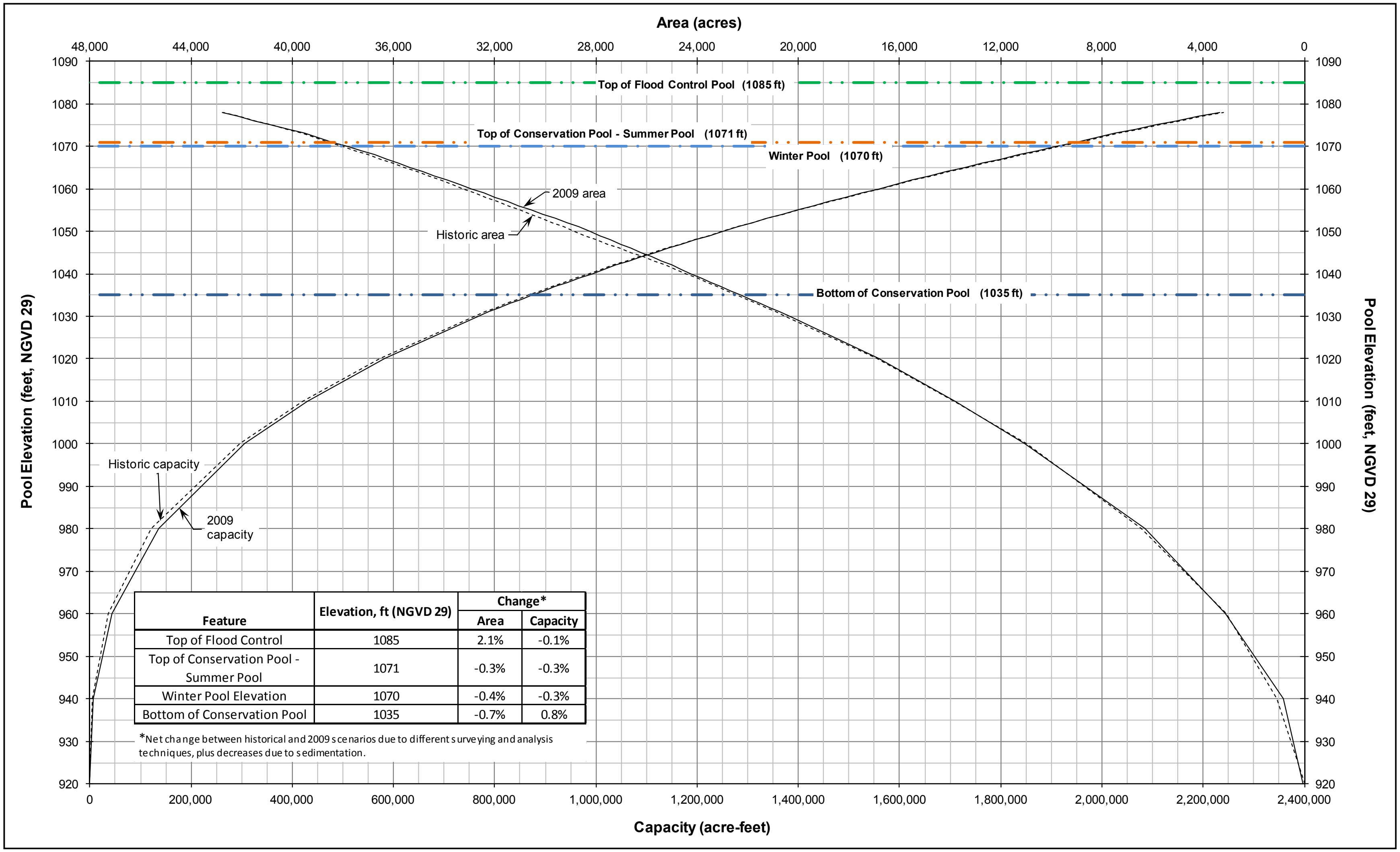
1954-58 was the most widespread, extreme and prolonged drought across the southern United States since the Dust Bowl of the 1930`s. The drought peaked in calendar year 1954; it was the driest of record statewide for Alabama since records began in 1895. Rainfall for 1954 was only 40 percent of normal across southeast Alabama.

1.5 1939-1943

Northwest Georgia experienced one of the driest springs of record in 1941. It was followed by drier than normal conditions across north Alabama during 1942-43.

Appendix E

Buford Area Capacity Comparison



Feature	Elevation, ft (NGVD 29)	Change*	
		Area	Capacity
Top of Flood Control	1085	2.1%	-0.1%
Top of Conservation Pool - Summer Pool	1071	-0.3%	-0.3%
Winter Pool Elevation	1070	-0.4%	-0.3%
Bottom of Conservation Pool	1035	-0.7%	0.8%

*Net change between historical and 2009 scenarios due to different surveying and analysis techniques, plus decreases due to sedimentation.

Figure E-1 Buford Dam (Lake Lanier) Storage-Area Comparison, Historic vs 2009

Appendix G

State and Regional Water Resources Planning and Activities Affecting the ACF Basin

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Summary of Water Planning, Management, and Conservation Activities Pursued by State and Regional Interests Affecting the ACF Basin

This appendix provides a general overview of water resource planning, management, and conservation activities by state, regional, and local interests in Georgia, Alabama, and Florida that have noteworthy implications for water resources in the Apalachicola, Chattahoochee, Flint rivers (ACF) Basin and update of the ACF water control manual. This section is not intended to provide in-depth detail on each of these activities or programs or to discuss every such activity within the ACF Basin by individual counties and municipalities, unless those efforts are part of one of the regional or state activities discussed below.

1 Georgia

1.1 Water Withdrawal Permit Program

Georgia laws—the Georgia Water Quality Control Act (O.C.G.A. 12-5-31) and the Georgia Groundwater Use Act (O.C.G.A 12-5-90 *et seq.*)—require any water user who withdraws more than 100,000 gal/d (monthly average) to obtain a withdrawal permit from the Georgia Environmental Protection Division (EPD). Permit holders generally must report their withdrawals by month. The law does not transfer to the permit recipient any property right to the water or water permit beyond the right to reasonable use of the water. The Georgia Water-Use Program collects the reported information under the withdrawal permit system and the drinking-water permit system and stores the data in the Georgia Water-Use Data System.

Before issuing a permit, Georgia EPD evaluates the reasonableness of the use by applying the criteria listed in the statute, including the number of persons using the water source; the nature, severity, or duration of any impairment adversely affecting availability for other users; any injury to public health, safety or welfare; the kinds of activities proposed; the importance and necessity of the uses and the extent of any injury caused to other water uses; diversion from or reduction in flows in other watercourses or aquifers; prior investment in land; and other relevant factors (O.C.G.A. 12-5-31(e)). M&I (municipal and industrial) permits are issued for a term of 10 to 50 years, after which they must be renewed. Farm use permits are issued for an unlimited term, except in the Flint River Basin, in which farm use permits issued after March 2006 have a term limit of 25 year (yr). M&I permits are issued for a specific quantity determined by reasonable use. Farm permits issued after 1991 also have defined quantities. Farm permits issued before 1991 are based on pump capacity as of July 1, 1988. The Georgia EPD can revoke M&I permits for extended periods of nonuse. Farm permits cannot be revoked after an initial use unless water was never withdrawn.

Surface water users for agriculture are required to obtain *Surface Water Withdrawal* permits if the threshold pumping rate (100,000 gal/d) and farm use conditions apply. All direct stream withdrawals must be permitted, and some will have low-flow limits for their use. Withdrawals from ponds might or might not require permits. Those that intercept intermittent or continually flowing streams that are considered waters of the state and ponds shared along property lines require permits. Ponds are also used to store groundwater. If a pond has no inflow except that pumped from a well, a groundwater permit is required for the well. If the pond intercepts runoff or streamflow and has water pumped in periodically from a well, a combined *Well-to-Pond Water Withdrawal Permit* is issued (Hook et al. 2009).

The Georgia EPD requires permits for wells withdrawing greater than 100,000 gallons per day (gal/d). Private wells withdrawing less than 100,000 gal/d are not regulated by the state. The Georgia EPD began permitting agricultural water withdrawals in 1988 following amendments to the Ground-Water Use Act of 1972. Wells installed before July 1, 1988, were grandfathered into the permitting program. Once issued, a permit cannot be revoked and does not expire, but it can be suspended or modified if the water withdrawn causes adverse effects on nearby water users or limits their use.

From 1999 to 2006 the Georgia EPD had a moratorium on farm-permit issuance in the lower Flint River Basin. Farm-use permits are issued for irrigation of general farming, aquaculture, pasture, turf production, orchards, nurseries, and water supply for farm animals; over 75 percent of the farm-use permits are for crop irrigation. As of 2006, nearly 50 percent of the irrigated cropland in the Flint River Basin was in cotton, and an additional 25 percent was in peanuts. Most wells for livestock and aquaculture irrigation use less than 100,000 gal/d and are not permitted (GADNR 2006).

During the moratorium, the Georgia EPD evaluated the Lower Flint Basin to determine how best to issue new agricultural water withdrawal permits to prevent overconsumption of groundwater. New permits require accurate latitude and longitude coordinates of proposed well and surface-water pump locations and depth of withdrawal, which the Georgia EPD uses to calculate the radius of influence and determine whether the proposed well will impact adjacent users or nearby springs and streams. If an impact would occur, the Georgia EPD modifies the permit as needed. The Georgia EPD no longer issues permits for wells in the Floridan aquifer that are within 0.25 mile of another well, unless it is shown through a hydrogeologic evaluation that the well will not cause or contribute to excessive drawdown of the neighboring well. Also, the Georgia EPD now conducts random site inspections to ensure that permittees are following permit and conservation guidelines. If a violation is found, the permittee has one growing season to correct it (GADNR 2006).

More detailed information on the water withdrawal permitting program can be found at http://epd.georgia.gov/water-withdrawal-permitting.

1.2 State Drought Management Plan

The 1998–2002 drought raised awareness in Georgia regarding drought impacts and interest in drought planning and management. The first *Georgia Drought Management Plan* was adopted by the Georgia DNR Board in March 2003 (GAEPD 2003a). The plan was developed using a collaborative approach involving stakeholders with interest and/or expertise in water-related matters. These stakeholders represented a geographical and political cross section of the state, as well as a cross section of business, industry, environmental, and water management interests. The Georgia General Assembly and the Board of Natural Resources have assigned the Director of the Georgia EPD principal responsibilities for implementing the drought management plan. Numerous agencies and organizations are tasked in this plan with some level of water resource or water-related management responsibilities. The Georgia EPD and those agencies and organizations must coordinate closely and share information about their drought or water conservation concerns and solutions.

The plan contains an array of pre-drought strategies, primarily oriented around water conservation. They are generally longer-term actions, implemented before a drought for the purpose of preparedness, mitigation, monitoring, and conservation. For example, during non-drought periods, municipal outdoor water use (other than specifically exempted activities) may occur only as follows: For odd-numbered addresses, outdoor water use is allowed on Tuesdays, Thursdays, and Sundays; for even-numbered addresses, outdoor water use is allowed on Mondays, Wednesdays, and Saturdays. As water conservation plans are developed by other agencies, regional development centers (RDCs), local governments, and water supply providers, they are to reflect the pre-drought strategies of the state plan (GAEPD 2003).

The State Climatologist's office and the Georgia EPD routinely monitor and evaluate streamflows, lake levels, precipitation, groundwater levels, and other climatic indicators that are supplied by several cooperating entities, principally the USACE (US Army Corps of Engineers), USGS (US Geological Survey), and the National Drought Mitigation Center. These drought indicators reflect the health of the hydrologic system. Georgia is divided into nine climate divisions (regions), and each division has several indicators.

When the indicators in one or more of the nine climate divisions dictate the possible need for a drought response declaration, the EPD Director consults with a designated Drought Response Committee (with state, federal, and stakeholder representatives) to determine the potential severity of the drought condition(s) and the expected impacts. The Director, in consultation with the Committee, then determines the appropriate level of response. Response guidance for each level of drought severity is provided by the plan, but particular drought conditions might require greater or lesser responses than those specified in the plan (GAEPD 2003).

During a declared drought, the EPD Director and, as appropriate, other members of the Drought Committee notify the local RDCs, local governments, and water supply providers as to the appropriate action to be taken. Press releases are prepared to explain the situation and state response requirements. The State Climatologist and the Georgia EPD continue to monitor the drought indicators for changing conditions, and they act in response to those changing conditions. As drought conditions improve, a conservative approach is taken before the Director acts to decrease the drought level (GAEPD 2003).

As an example of drought response actions that may be triggered under the plan, Georgia Rules and Regulations, Chapter 391-3-30-.04 (GAEPD 2004), specifically define those response actions required for outdoor water use under drought response levels of increasing severity:

391-3-30-.04 Outdoor Water Use Schedule during Declared Drought Response Levels

(1) The director of the EPD is authorized to make drought declarations.

(2) During declared drought conditions, outdoor water use, other than activities exempted in 391-3-30-.05, shall occur only during scheduled hours on the scheduled days.

(3) *Declared Drought Response Level One* – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m. and 4:00 p.m. to 12:00 midnight.

- (a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays, and Sundays.
- (b) Scheduled days for even-numbered addresses are Mondays, Wednesdays, and Saturdays.
- (c) Use of hydrants for any purpose other than firefighting, public health, safety, or flushing is prohibited.

(4) *Declared Drought Response Level Two* – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m.

- (a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.
- (b) Scheduled days for even-numbered addresses and golf course fairways are Mondays, Wednesdays and Saturdays.
- (c) The following uses are prohibited:
  - 1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.
  - 2) Washing hard surfaces, such as streets, gutters, sidewalks and driveways except when necessary for public health and safety.

(5) *Declared Drought Response Level Three* – Outdoor water use may occur on the scheduled day within the hours of 12:00 midnight to 10:00 a.m.

- (a) The scheduled day for odd-numbered addresses is Sunday.
- (b) The scheduled day for even-numbered addresses and golf course fairways is Saturday.

(c) The following uses are prohibited:
1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.
2) Washing hard surfaces, such as streets, gutters, sidewalks, driveways, except when necessary for public health and safety.
3) Filling installed swimming pools except when necessary for health care or structural integrity.
4) Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, golf carts.
5) Washing buildings or structures except for immediate fire protection.
6) Non-commercial fund-raisers, such as car washes.
7) Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls except when necessary to support aquatic life.

(6) *Declared Drought Response Level Four* – No outdoor water use is allowed, other than for activities exempted in 391-3-30-.05, or as the EPD Director may order.

Exemptions from the outdoor water restrictions in Chapter 391-3-30-.05 include capture and reuse of cooling system condensate or storm water, reuse of gray water, landscape water uses with reclaimed wastewater, irrigation of personal gardens, specific and limited exceptions for newly installed landscapes, specific and limited exemptions for golf courses water use, and specific and limited exemptions for businesses whose operations are dependent on outdoor water use (GAEPD 2004).

Most of the measures in the plan are short-term actions to reduce water demand during a drought, rather than long-term demand management. The plan does not encompass measures to control long-term water demand related to population growth, nor does it contain significant measures to manage the demand of the industrial and agricultural sectors. This is a limitation typical of state drought plans. The state is addressing these longer-term issues through the development of the statewide water plan and water conservation implementation plan (CRS 2008), summarized in Sections 1.4 and 1.6.

The 2006–2008 period of drought provided the first serious test of the plan. Level 1 drought was declared for entire state in June 2006, with progressively more severe declarations through early 2007, culminating in a Level 4 drought declaration for 61 northern and western counties (primarily along the Chattahoochee River, and some of the Flint River counties) in September 2007, including prohibition on most outdoor residential water use. In October 2007, Governor Perdue went beyond the Drought Management Plan's Level 4 actions by calling for a 10 percent cut in withdrawals by groundwater and surface water permit holders in 61 counties (CRS 2008).

The 2003 drought management is available at
http://drought.unl.edu/archive/plans/drought/state/GA_2003.pdf.

In 2014, the Georgia EPD Watershed Protection Branch began a process, including stakeholder meetings, to discuss the possible future rule changes. The purpose of this process is consider possible development of a Drought Management Rule that would replace the current Rules for Outdoor Water Use (391-3-30) and the 2003 Drought Management Plan. More information on the process to develop a new drought management rule may be found at http://epd.georgia.gov/development-possible-new-drought-management-rules.

1.3 Flint River Basin Regional Water Development and Conservation Plan

The Georgia EPD initiated the Flint River Regional Water Development and Conservation Plan (the plan) in October 1999 in response to growing concern over agricultural irrigation in southwest Georgia. Computer models of stream-aquifer relationships and surface water flows indicated that, under conditions of extreme drought and greatly increased irrigation, the Flint River and some of its tributaries could virtually stop flowing. The plan included a moratorium on the issuance of new farm use permits for the Floridan aquifer in southwest Georgia; however, it also called for extensive scientific study of stream-aquifer relations and agricultural water use, and the creation of an Advisory Committee to assist the Georgia EPD in crafting the plan (McDowell 2005).

Development of the plan was precipitated by:

- Growing recognition that drought-year agricultural irrigation from the Floridan aquifer in southwest Georgia could affect streams hydraulically connected to the aquifer, as documented in a 1996 report issued by USGS. Specifically, groundwater baseflow to the Flint River and several major tributaries could become negative, which, coupled with already low surface water flows, could lead to brief periods of actual drying of some stream segments (Torak and McDowell 1996). This would threaten the endangered species of Unionid mussels native to the lower Flint River Basin. It could also lead to contamination of the Floridan aquifer (McDowell 2005).
- A 4 yr period of drought began in 1998. This led to an increase in the number of farmers seeking farm-use withdrawal permits in southwest Georgia. By spring 1999, hundreds of permit applications had been received, prompting the Georgia EPD Director to place a moratorium on new Floridan aquifer permits in the lower Flint River Basin (McDowell 2005).

In addition to the moratorium, a series of studies of agricultural practices in the region, metering of irrigation systems, additional hydrogeologic investigations, and other technical studies were pursued, along with significant stakeholder involvement (McDowell 2005).

The planning process was completed in 2006. The goals of the Plan, as defined by statute, are to promote conservation and reuse of water, guard against a shortage of water, promote the efficient use of water resources, and manage the water resources of the Flint River Basin such that they are sustainable and consistent with the public welfare. The moratorium on new farm-use permits was lifted, but applications are closely evaluated to meet the requirements of the plan. Permitting decisions are based on the requested amount of water, the connections between groundwater and surface water as determined by computer models, the impact of water withdrawals on streamflows, and the presence of endangered or threatened species (GAEPD 2006).

The Plan is available at http://www1.gadnr.org/frbp/index.html.

1.4 Georgia Statewide Water Management Plan

The 2004 Comprehensive Statewide Water Management Planning Act authorized the development of the Statewide Water Management Plan (SWP). The act established the following goal: “Georgia manages water resources in a sustainable manner to support the state’s economy, to protect public health and natural systems, and to enhance the quality of life for all citizens.” The Georgia EPD was charged with developing a draft of the plan, with oversight by the Water Council. Created by the act, the Water Council is a coordinating committee composed of the heads of eight state agencies with water-related responsibilities, four legislators, and two citizen members (GAEPD 2008).

Between January 2006 and July 2007, EPD used an intensive public involvement process to develop the draft plan. As required by the act, the draft plan was submitted to the Water Council by July 1, 2008. Drawing on additional public review and comment, the Water Council revised the plan and submitted it to the Georgia General Assembly in January 2009. By the end of February 2009, the plan had been adopted by the General Assembly and signed by the governor (Cowie and Davis 2009).

The SWP has three major components designed to address the goal for water management in Georgia: (1) Resource Assessments and Forecasting of Needs, (2) Tool Box of Water Management Practices, and (3) Framework for Regional Water Planning.

The SWP makes provisions to conduct resource assessments and generate long-range forecasts. The resource assessments focus on water quantity and water quality. The water quantity resource assessment addresses the amount of water that is available to withdraw for beneficial use, while still supporting the ability of downstream users, or users from the same aquifer, to benefit from that water resource. The water quality resource assessment addresses, from a watershed perspective, the wastewater treatment levels that are required to protect water quality. In addition, statewide and regional population and economic forecasts are translated in a consistent manner into water and wastewater demand forecasts over a 50 yr planning horizon (Cowie and Davis 2009).

The SWP explicitly recognizes that regional variation means that different sets of water management practices will be better suited to different parts of the state. The *toolbox* of water management practices includes demand management practices; water return practices such as onsite sewage management (septic systems) and centralized wastewater treatment; and water supply management practices such as surface water storage, inter- and intra-basin transfers, and aquifer storage and recovery. Water conservation is highlighted as a priority practice for use across the state by all water use sectors. Water quality management practices, including stormwater and nonpoint source pollution management, are also part of the toolbox (Cowie and Davis 2009).

The SWP provides a framework for regional water planning. Through regional water planning, water management practices will be selected and defined for implementation. Ten regional water planning councils have been formed to prepare recommended Water Development and Conservation Plans (WDCPs). Each council consists of 25 members that represent the water users and the water-related interests in each region. Council members are appointed by the governor, lieutenant governor, and speaker of the house.

WDCPs will characterize the water needs for each region as those needs relate to the needs of adjacent regions and the preferred water management practices to use in each region to close any gaps between water capacities and water needs. The councils will use the resource assessments and forecasts to develop the recommended WDCPs. Recommended plans will be submitted to the Georgia EPD for review, revision if needed, and ultimately adoption by the Georgia EPD Director. Under the 2004 act, water withdrawal permits and state loans for infrastructure projects must be consistent with the regional plans (Cowie and Davis 2009).

Resource assessments and the forecasts of water and wastewater needs were developed in 2010. Preparation of the WDCPs was fully underway in 2010. The first set of WDCPs was adopted in 2011. The 2004 act calls for review of the SWP every 3 yr to determine whether revisions are necessary. The regional WDCPs are to be reviewed and revised, as necessary, on a 3 to 5 yr cycle (Cowie and Davis 2009).

The state-wide water plan and pertinent documents are available at http://www.georgiawaterplanning.org.

1.5 Georgia Environmental Finance Authority Reservoir Study (2008)

In response to one of its mandates under the Georgia Water Supply Act of 2008 (O.C.G.A. 12-5-470), the Georgia Environmental Facilities Authority (GEFA) conducted an inventory and survey of feasible sites for multi-jurisdictional drinking water supply reservoirs in Georgia. The effort also considered reservoirs under development or specifically proposed, existing reservoirs with potential expansion volumes, and possible reservoir locations extracted from prior studies. The report was intended to provide information and preliminary analysis that can support decisions by local governments and Regional Planning Councils on how best to augment local water supply. The report is summarized in the following paragraphs (GEFA 2008). The study should complement the analyses conducted under the SWP.

The analysis focused on the 78-county area in Georgia above the Fall Line because the need for drinking water supply reservoirs in Georgia is sharply divided by geology at the Fall Line. Below the Fall Line (81 counties), groundwater aquifers are the principal source of public water supply and large underground aquifers function as their own natural water supply storage reservoirs. Above the Fall Line, surface water is the principal source of public water supply and man-made reservoirs are essential for water supply storage.

The study acknowledged that reservoirs are only one tool to increase water supply. Of all options, reservoirs are the most costly, environmentally sensitive, and time-consuming. The study recommended that (1) first consideration should be given to water conservation and efficiency measures and (2) communities should examine interconnectivity to other systems, as well as the potential for drilling wells.

When a region or community determines that a reservoir is the best alternative, priority should be given to the expansion of existing ones, then to development of regional reservoirs, and finally to single-jurisdiction facilities. There might be opportunities to expand existing reservoirs and evaluate existing and proposed projects for their ability to serve multiple jurisdictions. The study also recommended that communities explore opportunities to build impoundments on smaller streams, supplemented by pumping from large streams, rather than proposing reservoirs on large streams.

The analysis revealed that four existing reservoirs in the Georgia portion of the ACF Basin have potential for increased water supply yield by raising the existing dam to provide more storage volume combined with supplemental pumping from a nearby stream for reservoir filling. These opportunities are summarized in Table 1.

Table 1.
Existing reservoirs in ACF Basin (Georgia) with potential to expand volume (billion gallons [BG])

Name	County	River basin	Existing volume (BG)	Potential expansion volume (BG)	Final volume (BG)
Cane Creek Structure Number Two	Meriwether	Flint	1.1	3.44	4.54
Dog Creek Reservoir [a]	Douglas	Chattahoochee	1.28	4.16	5.44
Heads Creek Reservoir	Spaulding	Flint	2.5	1.5	4.0
Still Branch Reservoir	Pike	Flint	1.5	2.7	4.2

[a] Expansion of Dog Creek Reservoir was completed in 2009.

At the time of the study, one new water supply reservoir in the Georgia portion of the ACF Basin was under construction. Two proposed reservoirs in the Georgia portion of the ACF Basin were in various stages of planning/permitting in Georgia. These reservoirs are depicted in Table 2.

Table 2.
Reservoirs under development or proposed in the ACF Basin (Georgia)

Name	Counties served	Stream name	River basin	Status	Proposed yield
Lake McIntosh	Fayette	Line Creek	Flint	Under Construction[a]	10.4 mgd
Bear Creek Reservoir	Fulton	Bear Creek	Chattahoochee	Permitting	16.44 mgd
Glades Reservoir	Hall	Flat Creek	Chattahoochee	Permitting	6.4 mgd

[a] Construction was completed in 2012

Sixteen additional potential water supply reservoir sites in the Georgia portion of the ACF Basin were identified and inventoried from available prior studies and published reports (Table 3). Georgia has placed a high priority on progress toward increasing water supply availability, as evidenced by the significant investment that the state has made and will continue to make in the statewide water planning process. The SWP and the Regional Water Plans will make more comprehensive data and analysis tools available to guide future water supply planning.

Table 3.
Possible reservoir locations in the ACF Basin based on prior studies/investigations (Georgia)

Name	Counties served	Stream name	River basin
Anneewakee Creek	Douglas	Anneewakee Creek	Chattahoochee
Big Branch	Pike	Big Branch Creek	Flint
Future Reservoir	Coweta	Undetermined	Chattahoochee / Flint
Pelham Creek	Fayette	Pelham Creek/Whitewater Creek	Flint
Rose Creek	Upson	Rose Creek	Flint
Sweetwater Creek – Option 1	Douglas	Sweetwater Creek	Chattahoochee
Sweetwater Creek – Option 2	Douglas	Sweetwater Creek/Western Tributary to Sweetwater Creek	Chattahoochee
Unnamed Reservoir	Schley	Little Muckalee Creek	Flint
Unnamed Reservoir	Schley	Owens Creek	Flint
Unnamed Reservoir	Schley	Unnamed Tributary – Buck Creek	Flint
Unnamed Reservoir	Stewart	Little Creek/Wards Mill Branch	Chattahoochee
Unnamed Reservoir	Sumter	Ninemile Branch	Flint
Unnamed Reservoir	Sumter	Bear Branch	Flint
Unnamed Reservoir	Webster	Kinchafoonee Creek	Flint
Unnamed Reservoir	Webster	Christmas Branch	Flint
Unnamed Reservoir	Webster	Unnamed Trib – Slaughter Creek	Flint

The full GEFA study report is available at
http://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/document/GEFA-MACTEC-Inventory-Survey-Feasible-Reservoir-Sites.pdf .

1.6 Georgia Water Conservation Implementation Plan

In March 2010, the Georgia EPD published a comprehensive Water Conservation Implementation Plan (WCIP), designed to create a culture of conservation in the state and to guide Georgians toward more efficient use of the state's finite water resources (GADNR 2010a). The WCIP is a product of the Georgia SWP process. The plan provides a multi-pronged strategy to achieve more efficient and sustainable water use through conservation (defined as beneficial reduction in water use, water waste, and water loss) and measures to promote more efficient use of water (maximizing benefit from each gallon used). The plan was developed in conjunction with representatives of state agencies, local governments, and a wide range of stakeholder interests.

The WCIP provides specific goals and benchmarks for Georgia's seven major water use sectors.—agricultural irrigation; power generation, golf courses, industrial and commercial, landscapes, domestic and nonindustrial public uses, and state agencies. For each sector, the WCIP details water conservation goals, benchmarks, best practices, and implementation actions designed to reduce water waste, water loss, and, where necessary, water use.

The WCIP is used to guide decisions related to water use and water management by:

- Educating water users about water conservation practices and the goals they can accomplish
- Informing regional water plan preparation, which will be overseen by regional water planning councils
- Helping water use sectors collectively improve water use efficiency
- Informing Georgia DNR rule-making regarding water conservation requirements in permitting.

The WCIP program document is available at http://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/WCIP%20March%202010%20FINAL.pdf.

Conserve Water Georgia is a water conservation clearinghouse of the Georgia EPD (GADNR 2009). The focus of the clearinghouse is public information, education, and awareness. The site provides tips and tools for individuals, teachers and students, business and industry, and communities and local governments on conservation and water efficiency strategies.

Conserve Water Georgia promotes *waterSmart,* an education program designed to give Georgians information they need to successfully conserve water. The Cobb County-Marietta Water Authority developed *waterSmart* in 2000 for residents in its service area (http://www.watersmart.net), and the Georgia EPD began using the *waterSmart* brand in communications and education activities in 2006 to help residents statewide understand how to maintain their landscapes while using less water. The state *waterSmart* program was piloted in six communities (Albany, Augusta, Cobb County, Columbus, Dalton, and Macon) in 2007, and it went statewide through a partnership with University of Georgia Cooperative Extension in 2008.

Conserve Water Georgia promotes participation in USEPA's *WaterSense* program (http://www.epa.gov/watersense). *Watersense* can help consumers identify products and services that use less water while performing as well as or better than conventional models, thus saving natural resources, reducing water consumption, and saving money. *WaterSense* makes it easy to find and select water-efficient products with a label backed by independent testing and certification. *WaterSense* also recognizes some professional service programs that meet its specifications by incorporating a strong water efficiency component.

1.7 Governor's Water Contingency Planning Task Force (2009)

In response to the July 17, 2009, Federal District Court ruling that water supply was not an authorized purpose of Buford Dam/Lake Sidney Lanier, which would severely limit the ability to continue water supply withdrawals from the lake or conduct dam operations to meet downstream needs for metro

Atlanta, the Governor of Georgia outlined a four-part strategy. The strategy consisted of (1) appealing the ruling in court, (2) negotiating a mutually agreeable water allocation formula with Alabama and Florida, (3) pursuing congressional reauthorization of Lake Lanier for water supply, and (4) developing a contingency plan, to be implemented if the District Court ruling were to take effect. The Water Contingency Planning Task Force was created to evaluate the various options for a contingency plan and make recommendations to the governor. The Task Force included several dozen leaders from business, government, and environmental organizations. The following paragraphs summarize the report of the task force to the governor (Office of the Governor of Georgia 2009).

Implementing the District Court ruling would create a water supply shortfall for areas in the Metropolitan North Georgia Water Planning District in July 2012. The Task Force used a shortfall estimate of 280 mgd for planning purposes. Assuming that demand continued to grow as outlined in the Metro Water Plan, the corresponding water shortfalls in 2015 and 2020 were estimated to be approximately 310 mgd and 350 mgd, respectively.

The Task Force had two key objectives: (1) to develop a fact base to educate business and community leaders on Georgia's water situation and the implications of the District Court ruling and (2) to define a time-driven action plan that prioritized specific options and recommendations for conservation, supply enhancement, and water policy to address the potential shortfall.

Upon completing its evaluation, the Task Force concluded that Lake Lanier would be the best and most cost-effective water supply source for the Metro Atlanta region. The Task Force further concluded that the recommended contingency options, if required, would impose significant incremental economic costs and environmental impact on the region.

The Task Force did not foresee the ability of the region to meet the potential water shortfall in 2012, when the District Court ruling would take effect, even with extremely aggressive mandated conservation. Within this time frame, no new supply options could offer significant yield. By 2015, there is a potential contingency solution, consisting primarily of an indirect potable reuse project, along with a set of conservation measures and isolated groundwater options. The 2015 solution would, however, require significant up-front capital of approximately $3 billion and would supply water at an average incremental unit cost of $890 per million gallons (MG). By 2020, a broader set of more cost-effective options exists because reservoirs and transfers could be implemented. In that regard, the Task Force recommended a 2020 contingency solution that considers cost efficiency, environmental impact, and implementation feasibility criteria. This solution would include conservation measures and groundwater options that could be available for the 2015 solution, but it would replace the relatively expensive indirect reuse project with more cost-effective reservoir expansions (Tussahaw Creek in the Ocmulgee River basin and Dog River in the Chattahoochee River basin) and a new reservoir (Richland Creek in the Etowah River basin). The 2020 contingency solution would require a lower up-front capital requirement of approximately $1.7 billion and would have an incremental unit cost of $460/MG, which is nearly half the 2015 solution cost.

Although the supply options for 2015 and 2020 are identified as contingencies, the Task Force recommended that enhanced conservation, implemented through incentive-based programs, should be pursued regardless of the outcome of Lake Lanier reauthorization. This program of enhanced conservation was the basis for a set of Task Force recommendations on options to implement immediately, along with a supporting set of policy considerations, which are detailed in the Task Force report. There are three broad areas of additional conservation improvements that build on Metro Atlanta’s conservation progress to date, and they are reflected in these recommended policies:

- Institute mandatory data collection and reporting of key metrics to inform future planning efforts. For instance, utilities would have to conduct standardized water loss audits.

- Adopt higher water efficiency standards and incentive measures to increase conservation effectiveness (e.g., increasing incentives for fixture and soil meter retrofits).
- Link progress on conservation efforts to funding eligibility, low-interest loan qualifications, and permitting applications to ensure implementation of measures.

The Task Force recommended that contingency solutions should be pursued only if they are deemed absolutely essential, on the basis of the outlook of tri-state water negotiations, Lake Lanier reauthorization efforts, and the appeal of the District Court ruling. Per the Task Force, preference should be given to the 2020 contingency solution, if possible, and only if this action is required. In conjunction with the 2020 contingency solution, the Task Force also identified a set of policies that could support the implementation of mandate-based conservation measures envisioned within that contingency solution, also to be considered only if necessary to the support a contingency solution. The Task Force noted that the ability to implement a 2015 or 2020 solution within its stated time frame would also be contingent on initiating the necessary technical studies and permitting process swiftly, and implementation within such a time frame would not accommodate any unforeseen delays.

In June 2011, the 11^{th} Circuit Court of Appeals overturned the 2009 District Court ruling and confirmed that water supply was, in fact, and authorized project purpose of Lake Lanier. Thus, recommendations by the Governor's Task Force did not have to be implemented as an accelerated contingency plan to address severe short term water supply deficits. Nonetheless, much of the information developed by the Task Force has been utilized by state and local interests in subsequent water supply planning and management activities.

The full 2009 task force report is available at http://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/document/Water-Contingency-Planning-Task-Force-Report.pdf.

1.8 Georgia Water Stewardship Act of 2010 (HB-370)

In light of recent severe water resource management challenges in Georgia, (e.g. frequent droughts, rapid growth, and an unfavorable court ruling that could bar most water withdrawals from Lake Lanier) the General Assembly enacted the Georgia Water Stewardship Act in the 2010 legislative session. On the basis of recommendations from the 2009 Governor's Water Contingency Task Force, the legislation initiated a process for developing alternative supply sources while also reaffirming "the imminent need to create a culture of water conservation in Georgia."

Key provisions of the Water Stewardship Act include the following:

- Requirements for state agencies with water-related programs and responsibilities to review policies and programs encouraging water conservation and enhance water supply
- Mandates for public water systems serving over 3,300 individuals to implement best practices for water efficiency and conservation and to account for and mitigate water loss leaks
- Revisions to state minimum construction standards for new buildings, including use of high-efficiency plumbing fixtures and sub-metering of multi-unit buildings for water use
- Modification of state and local authority to impose outdoor watering restrictions
- Amendments to the permitting system for agricultural water withdrawals
- Creation of a joint legislative committee on water supply to examine opportunities for enhancing the state's water supply

Implementation of these provisions will require significant action by state agencies, local governments, and public water supply utilities over the next several years (UGA 2010).

1.9 Governor's Water Supply Program

In January 2011, Governor Nathan Deal directed GEFA to develop and launch the Governor's Water Supply Program (GWSP) and committed $300 million to the program over four years. The purpose of the GWSP is to align and mobilize the resources of the state of Georgia to assist local governments with developing new sources of water supply adequate to meet future water demand forecasts. The financial assistance is available in the form of low interest loans through GEFA and state direct investment through the Georgia Department of Community Affairs (DCA).

GEFA convened a Water Supply Task Force (WSTF) that provided expert guidance in the program's development and implementation. GEFA worked with DCA and other WSTF members to develop the report provided to the governor in December 2011, which outlined recommendations for the program. GEFA and DCA also held workshops designed to assist communities seeking funding through the program. In addition to water supply projects, GEFA's loan programs can finance a variety of water and wastewater infrastructure, including water conservation projects.

Applications for assistance under the GWSP are solicited annually. Through 2013, about $165 million has been committed to water supply projects, either in low interest loans or state direct investment. State financial assistance under the GWSP can be used for detailed planning and engineering, land acquisition, construction, and related activities associated with water supply projects.

More detail on the GWSP is available at the following web site: http://gefa.georgia.gov/governors-water-supply-program.

1.10 Metropolitan North Georgia Water Planning District

The Metropolitan North Georgia Water Planning District (MNGWPD or "Metro Water District") was created by the Georgia General Assembly in 2001 (O.C.G.A. 12-5-572) to serve as the water planning organization for the greater metropolitan Atlanta area. The MNGWPD's purpose is to establish policy, create plans, and promote intergovernmental coordination of water issues in the District from a regional perspective.

The MNGWPD includes 15 counties (Bartow, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Fulton, Forsyth, Gwinnett, Hall, Henry, Paulding, and Rockdale counties) as well as 92 municipalities partially or fully within these counties (Figure 1). The MNGWPD also has seven authorities that provide water, sewer, and/or stormwater services. The MNGWPD's plans and policies work to protect water resources in the Chattahoochee, Coosa, Flint, Ocmulgee, Oconee and Tallapoosa river basins. The area represented by the MNGWPD includes much of the Upper Chattahoochee River watershed. The District covers a total area of 4,800 sq mi, with approximately 4.8 million residents (MNGWPD 2008).

With the adoption of the SWP by the Georgia General Assembly in 2008, the MNGWPD became one of 10 regional water planning councils in the state. Accordingly, the work of the MNGWPD will continue within the integrated framework of statewide water resources planning.

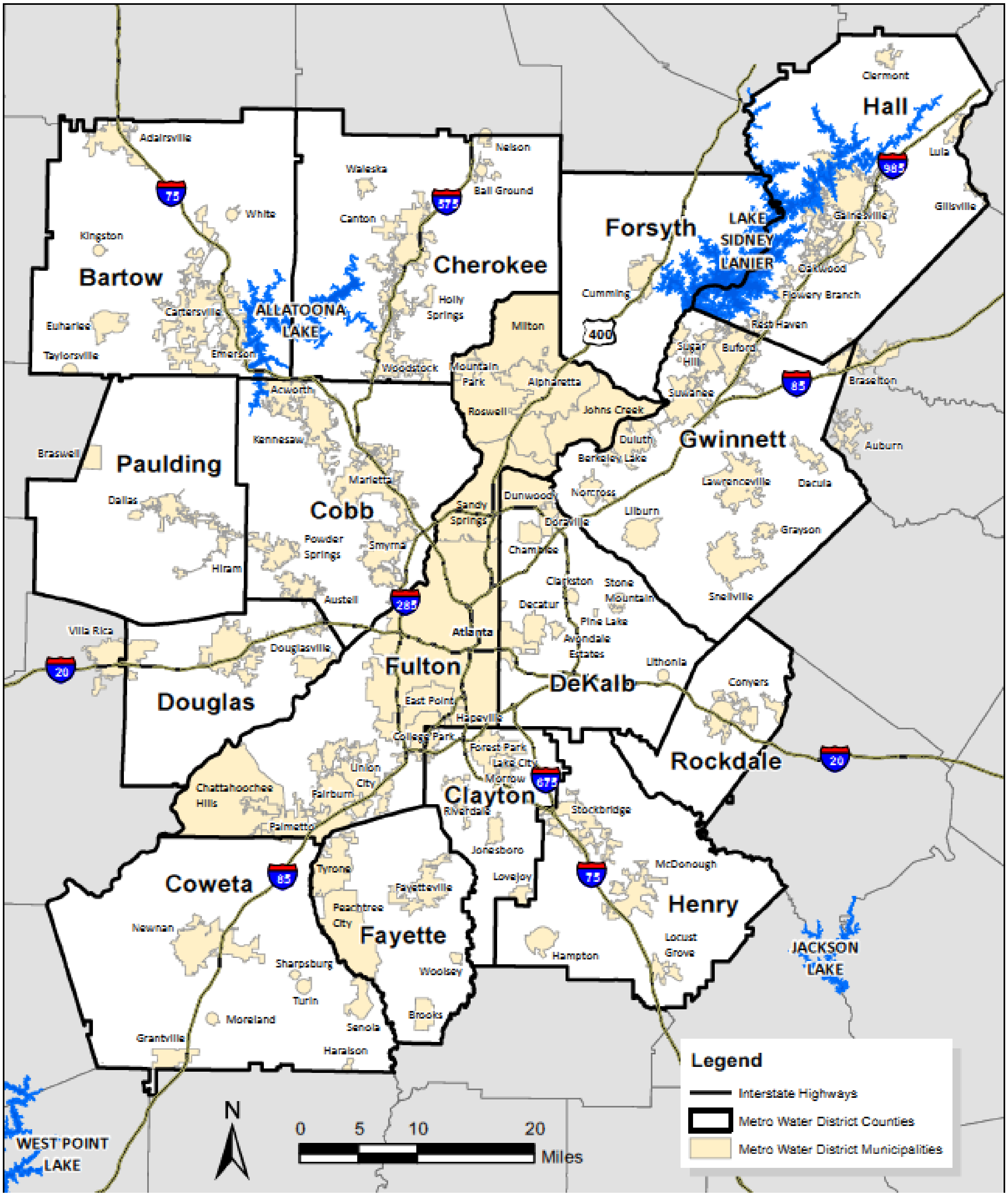


Figure 1. Metro North Georgia Water Planning District Area.

The MNGWPD enabling legislation mandated the development of three long-term regional plans to address the water resources challenges:

- Water Supply and Water Conservation Management Plan
- Wastewater Management Plan
- Watershed Management Plan

These three plans were developed concurrently, and they represent an integrated and holistic approach to water resources planning and management in the District (MNGWPD 2008).

The first plans were completed and adopted in 2003 and have been actively implemented by local jurisdictions in the MNGWPD. Updates to these plans were completed and published in May 2009 (MNGWPD 2008). The following paragraphs summarize the detailed strategies and recommendations for both effective water supply and water conservation as defined in the 2009 update to the Water Supply and Water Conservation Management Plan. The plan includes specific tasks and milestones for implementing these recommendations for local governments as well as regional and state agencies. The MNGWPD water resources plans are the result of a collaborative effort between the District's local jurisdictions, the Georgia EPD, and numerous stakeholders.

Existing Water Supplies. The MNGWPD relies primarily on surface water from rivers and storage reservoirs as its main source of water supply. In fact, surface water provides over 99 percent of the water supply in the District. Groundwater use makes up less than 1 percent of the public water supplies for the MNGWPD, due to bedrock geology. For the foreseeable future, it is expected that the percentage of groundwater use will remain fairly constant. Groundwater supply sources remain viable as a potential source for small towns and as a supplemental source during critical periods. Within the MNGWPD, almost 888 average annual day-million gallons per day (aad-mgd) of permitted water supply (surface and groundwater) is available. The Chattahoochee basin accounts for approximately 73 percent of the permitted available water supply in the MNGWPD. A summary of existing permitted monthly average available water supply by basin is presented in Table 4.

Table 4.
MNGWPD percent permitted
monthly average available water supply by basin

Source basin	Percent permitted monthly average available water supply
Chattahoochee	72.6%
Coosa	14.0%
Flint	5.0%
Ocmulgee	8.1%
Oconee	0.2%
Tallapoosa	0.1%

Water Supply Interconnections. Water supply service and management throughout the MNGWPD is provided by over 50 individual water providers. Water management includes supply, treatment, distribution, interconnections, and the interaction of these infrastructure systems with the natural systems. All 15 counties within the MNGWPD maintain interconnections with at least one other county for routine or emergency water sale. Some of these interconnections originally served as a primary water supply source before the water system in the receiving county was adequately developed. These connections are now kept for emergency uses. Interconnections with other water systems provide a valuable means of increasing water system reliability.

Interbasin Transfers. Interbasin transfers of water and wastewater occur among municipalities, counties, and basins in the MNGWPD. Transfers among basins are particularly common within counties that straddle the ridges between two or more basins. Interbasin transfers are a key and necessary element in supplying water throughout the MNGWPD; there are water supply and wastewater transfers into and out of every basin. Table 5 summarizes the existing water and wastewater interbasin transfers in the MNGWPD. The large net transfer from the Chattahoochee River basin to the Ocmulgee River basin is principally because of water withdrawals and returns in Gwinnett and DeKalb counties. While Lake Lanier (Gwinnett) and the Chattahoochee River (DeKalb) serve as primary water supply sources for the counties, only about one-third of their service areas are in the Chattahoochee River Basin. Consequently, a disproportionate share of the water supply withdrawals from the Chattahoochee River Basin for those counties is discharged into the Ocmulgee River Basin as treated wastewater.

Table 5.
Summary of existing net interbasin transfers

Source basin	Receiving basin	Net transfer (aad-mgd)[a,b]
Chattahoochee	Ocmulgee	100
Chattahoochee	Oconee	7
Coosa	Chattahoochee	14
Flint	Chattahoochee	2
Flint	Ocmulgee	5

a. Transfers estimated based on 2006 actual withdrawals and discharges.
b. aad-mgd (average annual day-million gallons per day).

Water Conservation Program. Water conservation is a critical element in meeting the water supply needs in the MNGWPD. When fully implemented, water conservation measures will reduce the MNGWPD's water demand by the end of the planning period. Much progress related to water conservation has been achieved since the adoption of the 2003 Water Supply and Water Conservation Management Plan. The MNGWPD's plan has been instrumental in making water conservation a priority in north Georgia. The MNGWPD is the only major metropolitan area in the country with more than 100 jurisdictions that is implementing such a comprehensive long-term water conservation program that is required and enforced.

The planning process reflected in the 2009 update to the MNGWPD's Water Supply and Water Conservation Management Plan first considered water conservation/efficiency before investigating new or expanded sources. The water conservation program in the 2009 plan is the result of extensive analysis of the 2003 program, evaluation of new methods and measures, and stakeholder involvement. Forty-five potential water conservation measures were identified and evaluated. Each potential conservation measure was ranked against three qualitative criteria—technology/market maturity, service area match, and customer acceptance/equity. The analysis detailed in the 2009 Plan update yielded a combination of measures that best met the ranking criteria and were determined to be cost-effective. The water conservation measures in this Plan update include and extend beyond the measures in the 2003 Plan. This update includes –

The 10 water conservation measures from the 2003 plan:

- Conservation pricing
- Replace older, inefficient plumbing fixtures

- Pre-rinse spray valve retrofit education program
- Rain sensor shutoff switches on new irrigation systems
- Sub-meters in new multifamily buildings
- Assess and reduce water system leakage
- Conduct residential water audits
- Distribute low-flow retrofit kits to residential users
- Conduct commercial water audits
- Implement education and public awareness plan

Strengthening three of these 10 water conservation measures:

- Irrigation meter pricing at 200 percent of the first-tier rate
- 1.28 gpf (gallons per flush) toilet rebate program only by 2014
- Minimum local education requirements and optional toolbox of examples is provided

Two new water conservation measures were added:

- Install 1.28 gpf toilets and low-flow urinals in government buildings
- Require new car washes to recycle water

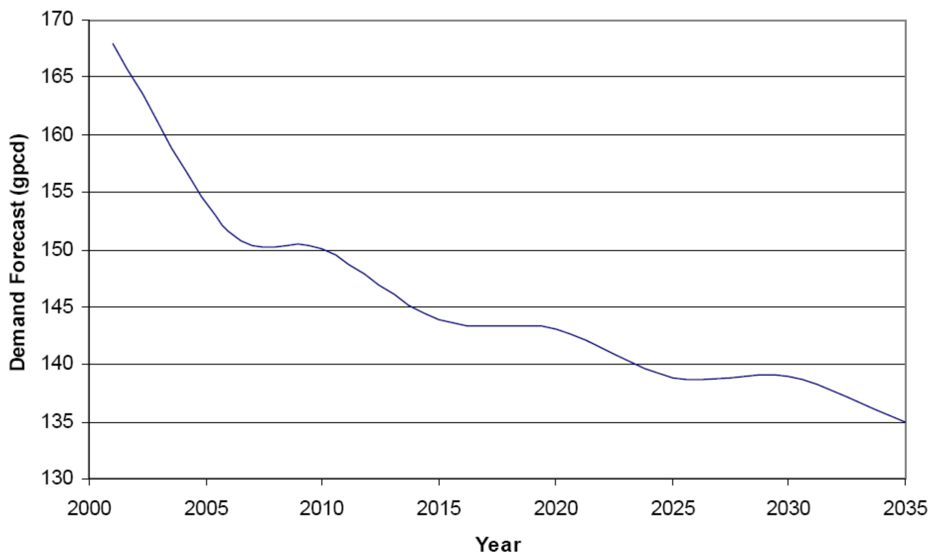
Tiered water conservation rates (where the more water used, the higher the price) have been put in place throughout the MNGWPD. By 2008, more than 99 percent of the population was subject to increasing block or tiered rates. All of the largest water systems have implemented programs to reduce system water loss. Toilet rebate programs are in place and ahead of schedule. In 2008, twenty-four water providers offered toilet rebates to eligible customers, either directly or as part of the MNGWPD's regional toilet rebate program.

Figure 2 shows that the 2009 MNGWPD plan update projects a 20 percent reduction in per capita demand from 2001 to 2035 (MNGWPD 2009). The starting point of 168 gallons per capita per day (gpcd) reflects billing data for 2001 collected for the 2003 Plan. The 2006 data shows 151 gpcd, used in the plan update. By 2020, per capita water use in the MNGWPD is projected to be about 143 gpcd. The end point (135 gpcd) in 2035 reflects the benefit of the conservation program in the plan update.

Note that studies subsequent to the 2009 Water Supply and Conservation Plan indicate that per capita use in the MNGWPD area has declined faster than the earlier projected rates (Maddaus and CH2M Hill 2011). This more rapid decline in per capita water use in the area is principally due to increased water use restrictions and conservation measures associated with the 2006-2008 drought which have become more institutionalized as well as the effect of the economic recession (beginning in 2008-2009). Water use in most of the MNGWPD has not returned to pre-2007 levels.

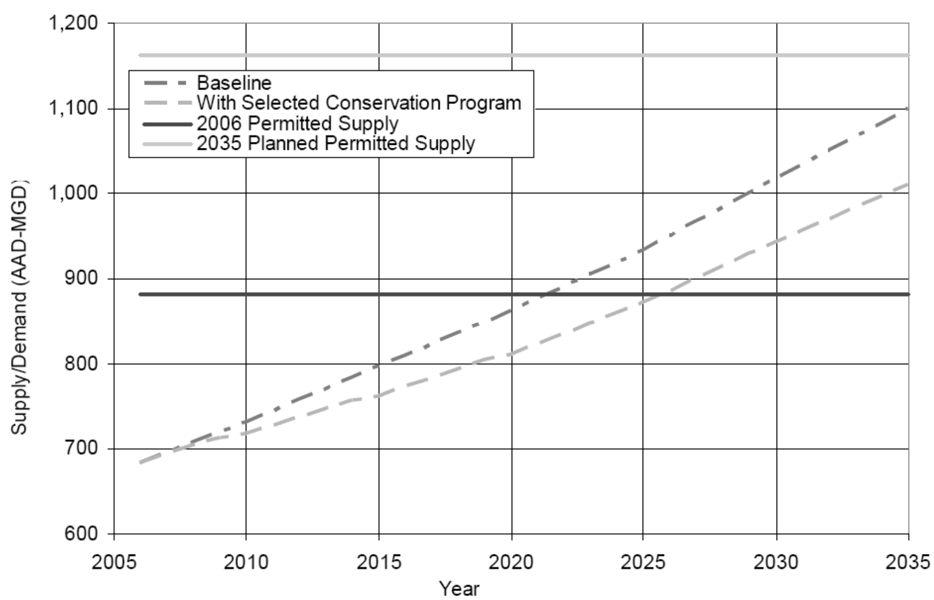
Future Water Supply Demands and Sources. With implementation of the enhanced water conservation program, the projected water demand within the MNGWPD is estimated to be 1,011 mgd by the year 2035 on an average annual daily demand basis. Figure 3 depicts present and projected future permitted water supplies and water demands, both with and without the enhanced water conservation measures. The current permitted surface water supply is 882 aad-mgd. With the conservation program, 2020 water demands are estimated to be about 810 aad-mgd. According to Figure 3, the current level of EPD-permitted water supply would meet demands (with enhanced conservation) through about 2026. The MNGWPD considered the benefits of the water conservation program (reduction in demand) before considering additional water supply sources.

To meet projected future water supply needs in the MNGWPD beyond 2026 through the 2035 planning period, additional water supply sources will be needed. The anticipated 2035 permitted surface water supply is 1,160 aad-mgd. Future water supply alternatives to meet 2035 demands within the MNGWPD include expanded use of existing water supply sources and reservoirs and construction of six additional water supply reservoirs; three are in the planning stages, and three others are needed within the planning horizon. Table 6 presents information on the six proposed reservoirs within the Metro North District. Two of those reservoirs (Bear Creek and Glades Reservoirs) are within the ACF Basin.



Source: MNGWPD 2009

Figure 2. Metro North Georgia Water District overall per capita water use trends (2001–2035) where overall per capta use is the total water demand supplied by public water systems in the MNGWPD divided by the MNGWPD's population.



Source: MNGWPD 2009

Figure 3. Metro North Georgia Water District water demand and supply.

Table 6.
Planned water supply reservoirs in the MNGWPD

Reservoir	Owner/operator using resource	Basin	Estimated size and yield
Glades Reservoir	Hall County	Chattahoochee	The 733-ac reservoir with an estimated yield of 6.4 mgd will release water to Lake Lanier. Currently in the permitting process.
Bear Creek Reservoir	Proposed South Fulton Water Authority	Chattahoochee	Impoundment on Bear Creek, a tributary of the Chattahoochee River. Estimated yield is 15 mgd.
Richland Creek Reservoir	Paulding County	Coosa	A 305-ac reservoir with an estimated yield of 35 mgd is in the permitting process on Richland Creek.
Etowah Reservoir	Fulton County	Coosa	Fulton County is considering a reservoir with a proposed 30 mgd yield.
Ocmulgee Reservoir	Henry County Water and Sewer Authority	Ocmulgee	A new reservoir is being considered in the Ocmulgee Basin with a proposed 13 mgd yield.
Cedar Creek Reservoir	Gainesville-Hall County	Oconee	The Cedar Creek reservoir is expected to have a yield of 9 mgd and be supplemented with water from the North Oconee River.

Source: MNGWPD 2009

Water Reuse. Several types of water reuse may be used in the MNGWPD to extend supplies or replace potential new water sources. The District plan outlines the different types of water reuse and discusses existing and future applications identified within the District to meet the 10 percent reuse planning standard identified by the Georgia EPD.

Non-potable reuse and indirect potable reuse are both practiced in the MNGWPD and are expected to sustain water supplies into the future. Indirect potable reuse is highly encouraged, where appropriate. Non-potable reuse is acceptable depending on each local community's consumptive use challenges, when it offsets an existing potable water supply.

Long-term sustainability of the water resources in the upper ACF Basin can be achieved through returning reclaimed water to Lake Lanier. The Metro District's Wastewater Management Plan calls for cities and counties that withdraw water from Lake Lanier for drinking water supply to maximize the return of reclaimed water to the lake. Summing both planned and incidental indirect potable reuse, communities plan to return more than 100 aad-mgd to Lake Lanier within the 2035 planning horizon, outlined in the District's Wastewater Management Plan.

The MNGWPD has assumed in its planning efforts to date that the federal reservoirs (Lake Lanier in the ACF Basin and Lake Allatoona in the Alabama-Coosa-Tallapoosa [ACT] Basin) will continue to operate to meet water supply needs within the District consistent with the guidance about future yield expectations provided by the Georgia EPD.

More information on the MNGWPD program is available at http://www.northgeorgiawater.org/. The 2009 Water Supply and Conservation Plan document is available at http://www.northgeorgiawater.org/plans/water-supply-and-water-conservation-management-plan. Since the publication of the 2009 plan, several conservation-related amendments have been made to the plan in response to state legislation. The amendment are available at http://northgeorgiawater.org/wp-content/uploads/2015/05/Amendments-to-District-Water-Supply-Conservation-Mgmt-Plan_June-16-2015.pdf. The 2009 plan is in the process of being updated in 2016.

2 Alabama

2.1 Alabama Office of Water Resources/Alabama Water Resource Commission

The Alabama Water Resources Act (Act Number 93-44, codified as Code of Alabama 1975, Article 9-10B-1, et seq.) legislatively established the OWR, a division of the Alabama Department of Economic and Community Affairs.

The Alabama OWR plans, coordinates, develops, and manages Alabama's water resources (both groundwater and surface water) in a manner that is in the best interest of Alabama. This includes recommending policies and legislation, conducting technical studies, implementing and participating in programs and projects, and actively representing Alabama's intra- and interstate water resource interests (ALOWR 2010).

The Alabama Water Resources Commission provides oversight to the Alabama OWR and serves in an advisory capacity to the governor and presiding officers of the state house and senate. The Commission consists of 19 voting members selected by the governor, the lieutenant governor, and the speaker of the House of Representatives. Members serve 6 yr, staggered terms. The Alabama Water Resources Act requires that Commission membership include representatives from each congressional district and each major surface water region of Alabama. In addition to the geographic representation requirements, the membership must also represent a cross section of water user groups, including rural and urban public water systems, non-public (e.g., industrial, manufacturing) commercial navigation, conservation, and the environment or water-based recreation interests within Alabama (ALOWR 2010).

More information on the Alabama Water Resources Commission and OWR is available at http://adeca.alabama.gov/Divisions/owr/Pages/default.aspx.

2.2 Alabama Drought Management Plan

Alabama has developed a Drought Management Plan (final), dated May 22, 2013 (ALOWR 2013). The plan is administered and coordinated by the Alabama OWR, working closely with numerous local, state, and federal agencies and other water resources professionals to pursue a statewide approach to drought planning and management. The following paragraphs provide a summary of the plan.

The purpose of the Alabama Drought Management Plan is to minimize the impact of drought, to develop action plans to be used during a drought, and to reduce the risk of drought disasters. The plan outlines both long- and short-term measures to be used to mitigate the effects of drought and to respond to drought conditions. To accomplish these goals, the plan:

- Defines a process to address drought and drought-related activities, such as, monitoring, vulnerability assessment, mitigation, impact assessment, and response
- Identifies long- and short-term activities that can be implemented to reduce and prevent drought impacts
- Identifies local, state, federal, and private-sector entities that are involved with state drought management and defines their responsibilities
- Acts as a catalyst for the creation and implementation of local drought response efforts

While there is no way to prevent a drought from occurring, the adverse effects of a drought can be reduced or mitigated through the implementation of the plan. The impact of drought can be reduced by improving the overall forest health, which reduces the risk of drought-caused fires; improving and maintaining water systems, which will reduce pumping failures; establishing and implementing contingency plans (such as predetermined water conservation measures); or designating alternative emergency water sources.

The plan creates a statewide regional structure to identify the different areas affected by drought conditions; identify risks associated with drought conditions; identify ways to possibly avoid droughts; and, when drought emergencies cannot be avoided, identify ways to mitigate the impacts of droughts. These objectives are accomplished by developing drought triggers and indicators and by providing guidance on responses to drought conditions for the various sectors affected by droughts.

In the plan, the Alabama Drought Assessment and Planning Team (ADAPT) has been established to serve in an advisory capacity to Alabama OWR and the Governor's Office, as needed, and to coordinate intergovernmental drought response and management in the implementation of all drought-related activities. ADAPT is composed of members from several Alabama agencies, the U.S. Department of Agriculture (USDA), the chairman of the Monitoring Advisory Committee (MAG), and the chairman of the Drought Impact Group (DIG). The MAG provides technical support to ADAPT and is composed of representatives from federal, state, and local agencies and other water resources professionals. The DIG provides drought impact and mitigation support to ADAPT, is responsible for identifying drought impacts on water users, and is representative of the following five drought impact sectors: domestic, agricultural, environmental, industrial, and recreational. Each subgroup comprises state, local, private, and nonprofit organizations and works on issues that encompass more than one drought sector.

The state is divided into nine specific regions, and drought indicators have been determined for each region. When the drought indicators begin to show the potential onset of drought conditions, the Alabama OWR, in coordination with ADAPT and the MAG, declares appropriate drought stage determinations with increasing levels of severity (advisory, watch, warning, emergency) as the drought deepens.

Upon the inception of a new or increased drought alert phase, the ADAPT is responsible for disseminating public information concerning all aspects of the drought. The initial action in responding to drought must be public education—providing information as to existing and potential conditions and water conservation measures necessary to meet the demand presented at each drought watch phase.

Drought triggers do not automatically invoke a required response from the various categories of water users. The triggers do prompt additional monitoring and notices to the water systems and public regarding the ongoing drought conditions. The Alabama OWR, in coordination with ADAPT, notifies the local governments and water utilities regarding the severity of the drought, makes recommendations, and provides guidance on the appropriate actions to be taken during the four stages of drought.

The Alabama Drought Management Plan is available at http://www.adeca.alabama.gov/Divisions/owr/Documents/ALDroughtPlan.pdf.

2.3 Alabama Water Use Reporting Program

The Alabama OWR is mandated to administer Alabama's Water Use Reporting Program. This program requires that major non-public and irrigation water users that have the capacity to withdraw at least 100,000 gal/d of surface water and/or groundwater, as well as all public water systems, register their use with the Alabama OWR and obtain a Certificate of Use. Users are not required to obtain water withdrawal permits (ALOWR 2010).

Detailed information on the water use reporting program is available at http://adeca.alabama.gov/Divisions/owr/Pages/WaterManagement.aspx.

2.4 Water Conservation Program

In addition to the Alabama Drought Management Plan, which specifically supports conservation efforts during periods of drought, the state actively encourages voluntary water conservation/water efficiency initiatives on the Alabama OWR web site (ALOWR 2010). The web site promotes and maintains conservation tips on indoor and outdoor water use. The tips include links to assist (1) residential customers to investigate water-saving opportunities in each area of the home; (2) agricultural interests to consider adapting conservation practices that are used on agricultural land across the country to conserve and improve natural resources for use on their land; and (3) municipal water planners with step-by-step approaches and conservation measures that can be used to develop and implement plans for water conservation. The web site also provides a sample Water Conservation Ordinance for use by municipal and county government officials.

More information on the water conservation program is at http://adeca.alabama.gov/Divisions/owr/Pages/Drought.aspx#Water .

2.5 Alabama Water Agencies Working Group (AWAWG)

In August 2011, Governor Bentley called together four agencies of state government with water resource responsibilities to develop an overview of water issues and activities. The four agencies included: Alabama Department of Community Affairs, Office of Water Resources (ALOWR); Alabama Department of Conservation and Natural Resources (ADCNR); Alabama Department of Environmental Management (ADEM); and the Geological Survey of Alabama (GSA). The Governor decided in April 2012 to continue and expand this work by formalizing the Alabama Water Agencies Working Group (AWAWG). Soon thereafter, a fifth agency, the Alabama Department of Agriculture and Industries, was added to the AWAWG.

Governor Bentley directed the AWAWG to recommend an action plan and timeline for implementing a statewide water management plan by December 1, 2013. As part of the action plan process, AWAWG was tasked to establish a comprehensive database of Alabama's water resources and conduct meetings to gather input from stakeholders interested in water resource issues. The work of the AWAWG is coordinated by a chairman appointed by the Governor. Six subcommittees were created to help carry out the group's responsibilities and provide focus to the following specific topics: legal; database; stakeholders; legislation; reporting; and public information.

AWAWG prepared and submitted a report to the Governor on August 1, 2012 entitled *Water Management Issues in Alabama* (AWAWG 2012). The report represented an interim step in response to the Governor's directive. It identified and summarized a dozen key water issues for the state and associated policy options. The water and related issues identified included:

- Water Resources Management Plan
- Expanded Certificates of Use / Permitting
- Economic Development
- Surface Water and Groundwater Availability
- Drought Planning
- Water Conservation and Water Reuse
- Interbasin Transfers

- Instream Flows
- Interstate Coordination
- Water Resources Data
- Key Stakeholder Education and Outreach
- Public Education and Outreach

AWAWG reaffirmed the need for a statewide water management plan so that Alabama can address these issues responsibly and effectively. The August 2012 report was intended to provide a common base of information to assist various water agencies and others interested in water resource matters to take the first steps toward resolving policy issues and creating a comprehensive water management plan for Alabama.

The December 2013 report responding to the Governor's directive summarized actions taken by AWAWG through the August 2012 *Water Management Issues in Alabama* report and subsequent steps to develop and recommend a conceptual framework for a comprehensive state-wide water resource management plan. The recommendations were developed with substantial stakeholder participation. The conceptual framework included a vision statement, guiding principles, and an action plan addressing all twelve water resource issue areas identified in the August 2012 report. Recommended actions to implement a state-wide water management plan included the following considerations: identification of responsible agencies; estimated costs; relative priorities; and proposed timelines for implementation (AWAWG 2013).

More detailed information on AWAWG is available at http://adeca.alabama.gov/Divisions/owr/awawg/Pages/default.aspx.

3 Florida

3.1 Florida Water Plan

The Florida Water Plan is the Florida DEP's principal planning tool for long-term protection of the state's water resources (FLDEP 2001). It was developed pursuant to section 373.036, Florida Statutes (F.S.), which requires that it specifically include:

- The programs and activities of the Department related to water supply, water quality, natural systems, flood protection, and floodplain management
- The water quality standards of the Department
- The District Water Management Plans (including regional water supply plans) of the five regional water management districts
- The Water Resource Implementation Rule (Ch. 62-40, Florida Administrative Code)

Florida has a system of five regional water management districts under the general supervision of the Florida DEP. Together, DEP and the water management districts share a broad range of responsibilities related to water supply, flood protection and floodplain management, water quality, and protection of natural systems. This system strikes a balance between the need for statewide consistency and the need for regional flexibility. Figure 4 is a graphic representation of this system.

The plan is intended to help DEP, especially the Division of Water and the six DEP regulatory districts, to focus on the highest water resource protection priorities, organize its own water management responsibilities, and build water management partnerships. It identifies significant water resource management priorities facing the state and sets forth strategies and actions for addressing them. Specifically, the plan:

- Identifies what the DEP regards as the priority water issues
- States the DEP's main strategies for addressing the priority issues
- Focuses on accountability and performance measures
- Emphasizes the use of watershed management to achieve the DEP's water resource protection goals and aids in the statewide development and coordination of the watershed management approach
- Emphasizes the best use of current information technology to set priorities, assess effectiveness, and improve public access to data pertaining to protection activities identified in the plan
- Seeks to strengthen partnerships with the water management districts and other parties

Each year the DEP reports on the progress of the specific action steps provided in the Florida Water Plan, as well as other performance measures found in the plan. Typically the performance measures evaluate environmental health or track the accomplishment of specific tasks.

The Florida Water Plan web site is http://www.dep.state.fl.us/water/waterpolicy/fwplan.htm.

Figure 4. Florida Water Management Plan.

3.2 Water Conservation

In 2001, during one of the worst droughts in Florida's history, the DEP began an initiative to identify additional measures to increase water use efficiency. The initiative was an open process in which the DEP, in close coordination with the state's five water management districts, facilitated public meetings to develop specific water conservation recommendations. The final report (April 2002) contained 51 priority recommendations for improving water use efficiency and led to a *Joint Statement of Commitment for the Development and Implementation of a Statewide Comprehensive Water Conservation Program for Public Water Supply* (JSOC). The JSOC is a written agreement by key public water supply partners in Florida to collaborate on measures to improve water use efficiency.

Subsequent to the signing of the JSOC, and based on it, the 2004 regular session of the Florida Legislature enacted House Bill 293. Among other things, the bill creates a new section 373.227, F.S., encouraging the use of efficient, effective, and affordable water conservation measures, and it states that a goal-based, accountable, tailored water conservation program should be emphasized for public water supply utilities (FLDEP 2004).

In the legislation, the DEP was directed to "develop a comprehensive statewide water conservation program for public water supply." That is to be done "in cooperation with the water management districts and other stakeholders." The legislative action affirmed the collaborative approach used in the JSOC. The legislation was enacted to support and provide guidance to the general direction that the JSOC signatories had already embarked upon. In addition to paraphrasing portions of the JSOC and authorizing the Florida DEP and the water management districts to adopt rules needed to carry out the intended purpose, the legislation required that a written report be submitted to the Florida Legislature by December 1, 2005 (FLDEP 2004).

On the basis of the principles of the JSOC, the signatories developed a work plan (completed in December 2004). The work plan details the specific tasks, interim milestones, completion dates, estimated costs and potential funding sources, and assignment of responsibilities to (FLDEP 2004):

- Develop standardized definitions and performance measures for water conservation data collection and analysis
- Establish a clearinghouse for water conservation programs and practices
- Develop and implement a standardized process for public supply utilities to participate in the statewide water conservation program for public supply
- Develop and maintain a Florida-specific water conservation guidance document to assist public water suppliers in designing and implementing a utility-specific water conservation program
- Implement pilot projects through cooperative agreements with volunteer utilities
- The following DEP web site contains additional information on JSOC and state water conservation policies: http://www.dep.state.fl.us/water/waterpolicy/conservation.htm.

3.3 Conserve Florida Water Clearinghouse

The Conserve Florida Water Clearinghouse is hosted by the University of Florida and supported by the water management districts, the Florida DEP, and several associations and public utilities in the state with an interest in water resource conservation. The mission of the Clearinghouse is to develop collaborative relationships with related programs and to collect, analyze, and make available reliable information and technical assistance to public water supply utilities and water managers for use in developing effective and efficient water conservation programs (University of Florida 2010).

The Conserve Florida web site is http://www.conservefloridawater.org/.

3.4 Northwest Florida Water Management District (NWFWMD)

The NWFWMD is one of five water management districts in the state created by the Water Resources Act of 1972. The water management districts are directly responsible for managing the quality and quantity of the state's waters in conjunction with the Florida DEP. The NWFWMD has worked for decades to protect and manage water resources in a sustainable manner for the continued welfare of people and natural systems across its 16 county region. The NWFWMD serves the following Florida counties: Bay, Calhoun, Escambia, Franklin, Gadsden, Gulf, Holmes, Jackson, Leon, Liberty, Okaloosa, Santa Rosa, Wakulla, Walton, Washington, and western Jefferson. The NWFWMD area of responsibility is depicted on Figure 5, which includes the Apalachicola River and Bay.

Figure 5. Northwest Florida Water Management District (NWFWMD 2005)

3.4.1 District Water Management Plan

Pursuant to section 373.036, Florida Statutes, the NWFWMD develops a Strategic Water Management Plan (SWMP) every five years to define the responsibilities of the District, as well as the agency's objectives, strategies and success criteria. This plan focuses on current strategies – those activities the District plans to undertake in the near term to accomplish its mission to protect and manage the water resources of northwest Florida in a sustainable manner for the continued welfare of its residents and natural systems. The plan defines the District's current strategic priorities, implementation activities, financial resources and performance measures. The most recent published version of the SWMP occurred in 2015.

Prior to 2006, the water management districts in Florida developed District Water Management Plans (DWMPs) and update them every 5 yr. The last update to the NWFWMD DWMP was completed in 2005 (NWFWMD 2005). The planning processes outlined below that were part of the DWMPs are now captured in the *Strategic Water Management Annual Work Plan Report.* The SWMP integrates major programs, including regional water supply planning, water resource development, water supply development assistance, minimum flows and levels, resource regulation, wetland mitigation, special projects, the Surface Water Improvement and Management program, technical assistance, land acquisition and management, and public outreach and education. Detailed District work plans and documents guide the implementation of these programs. Collectively, the District's programs and plans, and its budget, constitute a comprehensive approach to the interrelated issues that span the four major areas of responsibility (AORs):

1. ***Water Supply.*** *Promote the availability of sufficient water for all existing and future reasonable-beneficial uses and affected natural systems.* The District works with local governments, utilities, and state and federal agencies to plan appropriately for, and ensure the availability of, sufficient water supplies in a manner that meets the needs of the human community and sustains associated natural systems.
2. ***Flood Protection and Floodplain Management.*** *Maintain natural floodplain functions and minimize harm from flooding.* Emphasizing a nonstructural approach, including land acquisition and mapping of flood-prone areas, the District works to protect and, where necessary, restore natural floodplain functions and help to protect the health, safety, and welfare of the region's residents and the integrity of the region's natural systems.
3. ***Water Quality.*** *Protect and improve the quality of the District's water resources*. The District works with local governments, state and federal agencies, and regional stakeholders to protect and, where necessary, restore water quality.
4. ***Natural Systems.*** *Protect and enhance natural systems*. The District works in cooperation with state and federal agencies, local governments, and regional stakeholders to protect natural resources of regional significance in a comprehensive, integrated manner, to preserve and restore natural systems and maintain public benefits and compatible uses.

The DWMP communicates the District's most pressing water management issues and its key strategies to address them. Intergovernmental coordination is critical to the District in carrying out its responsibilities. The District forms partnerships with other levels of government that implement water management through planning, regulation, and acquisition, and service delivery programs. By maintaining close working ties with federal, state, regional, and local agencies, the District can draw upon and provide important resources, technical expertise, and knowledge to support effective water resource management and implementation of the plan.

The 2015-2016 Strategic Water Management Plan is available at http://www.nwfwater.com/Data-Publications/Reports-Plans/Water-Management-Plans.

3.4.2 Consumptive Use Permits

Through the Consumptive Use Program, the District's water supplies are allocated in a manner that is reasonable and beneficial, is in the public interest, and does not have a deleterious impact on existing legal users or the resource.

The NWFWMD operates regulatory programs that address, through rules, the consumptive use of water; the construction, repair, or abandonment of water wells and licensing of water well contractors; the safety of nonagricultural impoundments; agricultural and forestry surface water management facilities, including *farm ponds*; stormwater management systems; the artificial recharge of groundwater; and works of the District (NWFWMD 2010).

For consumptive use permitting purposes, the District is divided into three permitting areas within the NWFWMD boundary—Permit Areas A, B, and C. The six counties along the Apalachicola River corridor fall into the following permit categories: Gulf County (Area B, Area A for barrier islands); Franklin County (Area B, Area A for barrier islands); Calhoun County (Area C); Jackson County (Area C); Liberty County (Area B); and Gadsden County (Area A). Unless exempted by law or rule, the following criteria are used for consumptive use permitting requirements (NWFWMD 2010):

Ground Water Withdrawals

Permit Area A

- All non-exempt water uses regardless of well size or withdrawal amounts

Permit Area B

- Withdrawals that exceed an annual daily average of 100,000 gal; or
- Combined withdrawal capacity of the well(s) exceeds 1,000,000 gal/d; or
- Withdrawals from a well(s) 6 in or larger in diameter; or
- Any withdrawal for community public supply or bottled water use

Permit Area C

- Withdrawals that exceed 1,400,000 gal in any single day; or
- Withdrawals from a well(s) 10 in or larger in diameter; or
- Any withdrawal for community public supply or bottled water use

Surface Water Withdrawals (Regardless of Location)

- Withdrawals from a lake, pond, river, stream, or impoundment that exceed an average daily withdrawal of 100,000 gal, or exceed 1,000,000 gal on any single day or 10 percent of the baseflow of the supplying waterbody; or
- In Gadsden County, in addition to the above thresholds, surface water withdrawals using a pipe(s) or combination of pipes whose outside diameter(s) equals 4 in or larger; or
- Any withdrawal for community public supply or bottled water use

More information on water use permits in the NWFWMD area is available at http://www.nwfwmd.state.fl.us/permits.

The NWFWMD web site is http://www.nwfwmd.state.fl.us.

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Appendix H

ACF Basin Species Lists

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Appendix H

Selected Tables Related to Section 2.5

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**Table H-1.
Mammals known or potentially occurring in riparian and upland portions of the ACF Basin (USGS 2003)**

Latin name	Common name	Latin name	Common name
Blarina brevicauda	northern short-tailed shrew	*Nycticeius humeralis*	evening bat
B. carolinensis	southern short-tailed shrew	*Ochrotomus nuttalli*	golden mouse
Canis latrans	coyote	*Odocoileus virginianus*	white-tailed deer
Castor canadensis	American beaver	*Ondatra zibethicus*	muskrat
Corynorhinus rafinesquii	Rafinesque's big-eared bat	*Oryzomys palustris*	marsh rice rat
Cryptotis parva	least shrew	*Peromyscus gossypinus*	common mouse
Dasypus novamcinctus	nine-banded armadillo	*P. leucopus*	white-footed mouse
Didelphus virginiana	Virginia opossum	*P. polionotus*	oldfield mouse
		Perimyotis subflavus	Tricoloured bat
Eptesicus fuscus	big brown bat		
Geomys pinetisa	southeastern pocket gopher	*Procyon lotor*	common racoon
Glaucomys volans	southern flying squirrel	*Rattus norvegicus*	norway rat
Lasionycteris noctivagans	silver-haired bat	*R. rattus*	black rat
Lasiurus borealis	eastern red bat	*Reithrodontomys humulis*	eastern harvest mouse
L. cinereus	hoary bat	*Scalopus aquaticus*	eastern mole
L. intermedius	northern yellow bat	*Sciurus carolinensis*	eastern gray squirrel
L. seminolus	Seminole bat	*S. niger*	eastern fox squirrel
Lutra canadensis	northern river otter	*Sigmodon hispidus*	hispid cotton rat
Lynx rufus	bobcat	*Sorex longirostris*	southern shrew
Marmota monax	woodchuck	*Spilogale putorius*	eastern spotted skunk
Mephitis mephitis	striped skunk	*Sus scrofa*	wild pig
Microtus pennsylvanicus	meadow vole	*Sylvilagus aquatious*	swamp rabbit
M. pinetorum	woodland vole	*S. floridanus*	eastern cottontail
Mus musculus	house mouse	*S. palustris*	marsh rabbit
Mustela frenata	long-tailed weasel	*Tadarida brasiliensis*	Brazilian free-tailed bat
M. vison	mink	*Tamias striatus*	eastern chipmunk
Myocastor coypus	nutria	*Urocyon cinereoargenteus*	common gray fox
Myotis austroriparius	southeastern myotis	*Ursus americanus*	black bear
M. grisescens	gray myotis	*Vulpes vulpes*	red fox
Napaeozapus insignis	woodland jumping mouse	*Zapus hudsonicus*	meadow jumping mouse
Neotoma floridana	eastern woodrat		

Table H-2.
Reptiles known or potentially occurring in at least a portion of the ACF Basin (USGS 2003)

Latin name	Common name	Latin name	Common name
Agkistrodon contortrix	copperhead	*L. elapsoides*	scarlet king snake
A. piscivorus	cottonmouth	*L. getula*	common king snake[a]
Alligator mississippiensis	American alligator	*Macroclemys temmincki*	alligator snapping turtle
Anolis carolinensis	green anole	*Masticophis flagellum*	coach whip
Apalone ferox	Florida softshell	*Micrurus fulvius*	coral snake
A. spinofera	spiny softshell	*Nerodia erythrogaster*	plainbelly water snake[b]
Carphophis amoenus	worm snake	*N. fasciata*	banded water snake
Cemaphora coccinea	scarlet snake	*N. floridana*	Florida green water snake
Chelydra serpentina	common snapping turtle	*N. sipedon*	Midland water snake
Chrysemys picta	painted turtle	*N. taxispilota*	brown water snake
Clemmys guttata	spotted turtle	*Opheodrys aestivus*	rough green snake
Cnemidophorus sexlineatus	six-lined racerunner	*Ophisaurus attenuatus*	slender glass lizard
Coluber constrictor	black racer	*O. mimicus*	mimic glass lizard
Crotalus adamanteus	eastern diamondback rattlesnake	*O. ventralis*	Eastern glass lizard
C. horridus	canebrake timber rattlesnake	*Pituophis melano levcus*	pine snake
Deirochelys retizularia	chicken turtle	*Pseudemys concinna*	river cooter
Diadophis punctatus	ringneck snake	*P. floridana*	Florida cooter
Drymarchon corais	indigo snake	*Regina rigida*	glossy crayfish snake
Elaphe obsoleta	rat snake	*R. septembittata*	queen snake
Eumeces anthracinus	coal skink	*Sceloporus undulatus*	fence lizard
E. egregius	mole skink	*Scincella lateralis*	ground skink
E. fasciatus	five-lined skink	*Seminatrix pygaea*	black swamp snake
E. inexpectatus	southeastern five-lined skink	*Sistrurus miliarius*	pigmy rattlesnake
E. laticeps	broadhead skink	*Sternotherus minor*	loggerhead musk turtle
Farancia abacura	mud snake	*S. odoratus*	common musk turtle
F. erytrogramma	rainbow snake	*Storeria dekayi*	brown snake
Gopherus polyphemus	gopher tortoise	*S. occipitomaculata*	red-bellied snake
Graptemys geographica	common map turtle	*Tantilla coronata*	southeastern crowned snake
G. polchra	Alabama map turtle	*Terrapene carolina*	box turtle
Heterodon platirhinos	eastern hognose snake	*Thamnophis sauritus*	ribbon snake
H. simus	southern hognose snake	*T. sirtalis*	eastern garter snake
Kinosternon baurii	striped mud turtle	*Trachemys scripta*	common slider
K. subrubrum	eastern mud turtle	*Virginia striatula*	rough earth snake
Lampropeltis calligaster	mole kingsnake	*V. valeriae*	smooth earth snake

[a]Also known as black/eastern kingsnake; [b]Also known as redbelly/yellowbelly water snake.

Table H-3.
Amphibians known or potentially occurring in at least a portion of the ACF Basin (USGS 2003)

Scientific name	Common name	Scientific name	Common name
Acris crepitans	northern cricket frog	*H. cinerea*	green treefrog
A. gryllus	southern cricket frog	*H. femoralis*	pine woods treefrog
Ambystoma cingulatum	flatwoods salamander	*H. gratiosa*	barking treefrog
A. maculatum	spotted salamander	*H. squirella*	squirrel treefrog
A. opacum	marbled salamander	*Necturus alabamensis*	Alabama waterdog
A. talpoideum	mole salamander	*Notophthalmus perstriatus*	striped newt
A. tigrinum	tiger salamander	*N. viridescens*	eastern newt
Amphiuma means	two-toed amphiuma	*Plethodon glutinosus*	slimy salamander complex
Bufo americanus	American toad	*P. serratus*	southern redback salamander
B. fowleri	Fowler's toad	*P. websteri*	Webster's salamander
B. quercicus	oak toad	*Pseudacris crucifer*	spring peeper
B. terrestris	southern toad	*P. feriarum*	upland chorus frog
Cryptobranchus alleganiensis	hellbender	*P. nisrita*	southern chorus frog
Desmognathus aeneus	seepage salamander	*P. ocularis*	little grass frog
D. apalachicolae	Apalachicola dusky salamander	*P. ornata*	ornate chorus frog
D. auriculatus	southern dusky salamander	*Pseudobranchus striatus*	dwarf siren
D. conanti	spotted dusky salamander	*Pseudotriton montanus*	mud salamander
D. monticola	seal salamander	*P. ruber*	red salamander
D. ocoee	Ocoee salamander	*Rana capito*	gopher frog
D. guadramaculatus	blackbelly salamander	*R. calesbeiana*	american bullfrog
Eurycea cirrigera	southern two-lined salamander	*R. clamitans*	green frog/bronze frog
E. gultolineata	southern three-lined salamander	*R. grylio*	pig frog
E. quadridigitata	dwarf salamander	*R. heckscheri*	river frog
Gastrophryne cardinensis	eastern narrow mouth toad	*R. palustris*	pickerel frog
Gyrinophilus porphyriticus	spring salamander	*R. sphenocephala*	southern leopard frog
Haideotriton wallacei	Georgia blind salamander	*R. sylvatiza*	wood frog
Hemidactylium scutatum	four-toed salamander	*Scaphiopus nolbrokii*	eastern spadefoot toad
Hyla avivoca	bird-voiced treefrog	*Siren intermedia*	lesser siren
H. chrysoscelis	Cope's gray treefrog	*S. lacertina*	greater siren

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**Table H-4.
Invertebrate taxa identified from 14 streams in the ACF Basin sampled by USEPA during the National Wadeable Streams Assessment (WSA; USEPA 2006) and the National Rivers and Streams Assessment (NRSA; USEPA 2009)**

Class	Order	Family	Genus	Common name
Acari	Trombidiformes	Hygrobatidae	*Hygrobates*	water mites
		Lebertiidae	*Lebertia*	water mites
		Arrenuridae	*Arrenurus*	water mites
		Pionidae	*Forelia*	water mites
		Unionicolidae	*Koenikea*	freshwater mites
			Neumania	freshwater mites
		Oxidae	*Oxus*	freshwater mites
Crustacea	Amphipoda	Hyalellidae	*Hyalella*	scud
	Decapoda	Cambaridae		crayfish
		Paleamonidae	*Palaemonetes*	freshwater shrimp
	Isopoda	Asellidae	*Lirceus*	freshwater isopod
Insecta	Diptera	Psychodidae	*Psychoda*	moth flies
		Ceratopogonidae	*Bezzia/Palpomyia*	biting midges
			Dasyhelea	biting midges
			Mallochohelea	biting midges
			Probezzia	biting midges
		Chironomidae	*Ablabesmyia*	non-biting midges
			Brillia	non-biting midges
			Chironomus	non-biting midges
			Cladopelma	non-biting midges
			Cladotanytarsus	non-biting midges
			Coelotanypus	non-biting midges
			Conchapelopia	non-biting midges
			Cricotopus	non-biting midges
			Cricotopus/Orthocladius	non-biting midges
			Cryptochironomus	non-biting midges
			Cryptotendipes	non-biting midges
			Demicryptochironomus	non-biting midges
			Dicrotendipes	non-biting midges
			Microtendipes	non-biting midges
			Nanocladius	non-biting midges
			Natarsia	non-biting midges
			Nilotanypus	non-biting midges
			Nilothauma	non-biting midges
			Parachironomus	non-biting midges
			Paracladopelma	non-biting midges
			Parakiefferiella	non-biting midges
			Paralauterborniella	non-biting midges

Class	Order	Family	Genus	Common name
Insecta	Diptera	Chironomidae	*Parametriocnemus*	non-biting midges
			Paratanytarsus	non-biting midges
			Paratendipes	non-biting midges
			Phaenopsectra	non-biting midges
			Polypedilum	non-biting midges
			Procladius	non-biting midges
			Pseudochironomus	non-biting midges
			Rheocricotopus	non-biting midges
			Rheosmittia	non-biting midges
			Rheotanytarsus	non-biting midges
			Robackia	non-biting midges
			Saetheria	non-biting midges
			Stelechomyia	non-biting midges
			Stempellina	non-biting midges
			Stempellinella	non-biting midges
			Stictochironomus	non-biting midges
			Tanytarsus	non-biting midges
			Thienemannimyia	non-biting midges
			Tribelos	non-biting midges
			Xestochironomus	non-biting midges
		Dixidae	*Dixa*	dixids
		Empididae	*Hemerodromia*	empidids
		Simuliidae	*Simulium*	black flies
		Tabanidae	*Chrysops*	deer flies
		Tipulidae	*Hexatoma*	crane flies
	Megaloptera	Corydalidae	*Nigronia*	fishflies
	Coleoptera	Gyrinidae	*Dineutus*	whirligig beetles
		Dryopidae	*Helichus*	long-toed water beetles
		Elmidae	*Ancyronyx*	riffle beetles
			Optioservus	riffle beetles
			Promoresia	riffle beetles
			Stenelmis	riffle beetles
		Psephenidae	*Psephenus*	water penny beetles
		Hydrophilidae		water scavenger beetles
	Ephemeroptera	Ephemeridae	*Ephemera*	burrowing mayflies
			Hexagenia	burrowing mayflies
		Baetiscidae	*Baetisca*	mayflies
		Caenidae	*Caenis*	mayflies
		Baetidae	*Pseudocloeon*	mayflies
			Baetis	mayflies
		Isonychiidae	*Isonychia*	mayflies

Class	Order	Family	Genus	Common name
		Heptageniidae		flatheaded mayflies
	Odonata	Gomphidae	*Progomphus*	dragonflies
		Cordulegastridae	*Cordulegaster*	spiketails
		Coenagrionidae	*Argia*	narrow-winged damselflies
	Trichoptera	Hydropsychidae	*Ceratopsyche*	web-spinning caddis
			Cheumatopsyche	web-spinning caddis
			Hydropsyche	web-spinning caddis
			Nectopsyche	web-spinning caddis
			Diplectrona	web-spinning caddis
		Hyrdoptilidae	*Hydroptila*	microcaddisflies
		Philopotamidae	*Chimarra*	little black caddisflies
		Leptoceridae	*Oecetis*	long-horned sedges (caddisflies)
	Plecoptera	Leuctridae	*Leuctra*	tiny winter blacks (stoneflies)
		Perlidae	*Acroneuria*	common stoneflies
			Perlinella	striped stone (stoneflies)
Mollusca	Basommatophora	Ancylidae	*Ferrissia*	limpets
		Planorbidae	*Menetus*	ram's horn snails
		Physidae	*Physa*	bladder snails
	Veneroida	Corbiculidae	*Corbicula*	basket clams
		Sphaeriidae		finger nail clams
Oligochaeta	Lumbriculida	Lumbriculidae		segmented worms
	Haplotaxida	Naididae	*Nais*	segmented worms
			Bratislavia	segmented worms
			Dero	segmented worms
			Pristina	segmented worms
		Tubificidae	*Aulodrilus*	segmented worms
			Limnodrilus	segmented worms
		Megascolecidae		segmented worms
		Enchytraeidae		segmented worms

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Table H-5.
Distribution of fish, by river basin and ecoregion

Common and *scientific* names	**Apalachicola River Basin**	**Chattahoochee River Basin**		**Flint River Basin**	
	Coastal Plain Ecoregion	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*
PETROMYZONTIDAE					
Southern brook lamprey *(Ichthyomyzon gagei)*	X[1,2,3]	X[4,5]	X[4,5]	X[1,3,4]	X
ACIPENSERIDAE					
Gulf sturgeon *(Acipenser oxyrhynchus desotoi)*	X[2,3]	--	--	--	--
POLYODONTIDAE					
Paddlefish *(Polyodon spathula)*	X[12]			X[12]	
LEPISOSTEIDAE					
Spotted gar (*Lepisosteus osseus)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
Longnose gar *(Lepisosteus osseus)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
AMIIDAE					
Bowfin *(Amia calva)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
ANGUILLIDAE					
American eel *(Anguilla rostrata)*	X[1,2]	X[1,3,4,5]	--	X[1,3,4]	--
CLUPEIDAE					
Alabama shad *(Alosa alabamae)*	X[1,2,3]	X[1,3,4]	X[1,3,4]	X[3]	X[3]
Skipjack herring *(Alosa chrysochloris)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[3]	X[3]
Gizzard shad *(Dorosoma cepedianum)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Threadfin shad *(Dorosoma petenense)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
SALMONIDAE[6]					
Brook trout *(Salvelinus fontinalis)*	--	--	X[1,2,4]	--	--
Brown trout *(Salmo trutta)*	--	--	X[1,2,4]	--	--
Rainbow trout *(Oncorhynchus mykiss)*	--	--	X[1,2,4]	--	--
CYPRINIDAE					
Bluefin stoneroller *(Campostoma pauciradii)*	--	X[1,4]	X[1,4]	X[1,4]	X[1,4]
Goldfish *(Carassius auratus)*	--	X[1,4,5]	X[1,4,5]	--	--
Grass carp *(Ctenopharyngodon idella)*	X[13]	X[12]	X[12]	X[12]	

Common and *scientific* names	Apalachicola River Basin	Chattahoochee River Basin		Flint River Basin	
	Coastal Plain Ecoregion	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*
Bluestripe shiner *(Cyprinella[7] callitaenia)*	X[1,2]	X[1,4,8]	X[1,4,5]	X[1,4]	X[1,4]
Bannerfin shiner *(Cyprinella[7] leedsi)*	X[3]	--	--	--	--
Red shiner *(Cyprinella[7] lutrensis)*	--	--	X	--	--
Blacktail shiner (*Cyprinella[7] venusta)*	X[1,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Common carp (*Cyprinus carpio)*	X[1,2]	X[1,4,5]	X[1,4,5]	X	--
Silverjaw minnow (*Notropis buccatus)*	X[1,2]	X[1,4,5,8]	X[1,4,5,8]	--	X[1,4]
Clear chub (*Hybopsis winchelli)*	X[1,2,3]	X[1,3,5]	X[1,3,5]	X[1,3]	X[1,3]
Bandfin shiner *(Luxilus[7] zonistius)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Blacktip shiner (*Lythrurus[7] atrapiculus)*	--	X[1,3]	X[1,3]	--	--
Bluehead chub *(Nocomis leptocephalus)*	--	X[3,4,5]	X[3,4,5]	--	X[3]
Golden shiner *(Notemigonus crysoleucas)*	X[3]	X[1,3,4,5]	X[1,3,4,5]	X[3,4]	X[3,4]
Rough shiner *(Notropis baileyi)*	--	X[1,3,4,5]	X[1,3,4,5]	--	--
Ironcolor shiner *(Notropis chalybaeus)*	X[1,2,3]	X[2]	--	X[1,4]	--
Dusky shiner *(Notropis cummingsae)*	X[1,2,3]	X[1,4,5]	X[1,4,5]	--	--
Redeye chub *(Notropis harperi)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4,5]	--
Spottail shiner *(Notropis hudsonius)*	--	X[1,3,4]	X[1,3,4]	--	--
Highscale shiner *(Notropis hypsilepis)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Longnose shiner *(Notropis longirostris)*	X[1,2]	X[1,4,5]	X[1,4,5]	X[1,4]	X[1,4]
Yellowfin shiner *(Notropis lutipinnis)*	--	--	X[1,4,8]	--	--
Taillight shiner *(Notropis maculates)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
Coastal shiner *(Notropis petersoni)*	X[1,2,3]	X[8]	X[8]	X[1,3,4]	--
Weed shiner *(Notropis texanus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4,5]	--
Coosa shiner *(Notropis xaenocephalus)*	--	--	X[1,4,8]	--	--
Pugnose minnow *(Opsopoeodus emiliae)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4,5]	--

Common and *scientific* names	Apalachicola River Basin	Chattahoochee River Basin		Flint River Basin	
	Coastal Plain Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion
Fathead minnow *Pimephales promelas)*	--	--	X	X[3]	X[3]
Broadstripe shiner (*Pteronotropis[7] euryzonus)*	--	X[1,3,4,5]	--	X[3]	--
Sailfin shiner *(Pteronotropis[7] hypselopterus)*	X[1,2,3]	X[1,3,4,5]	--	X[2,4,5]	--
Flagfin shiner (*Pteronotropis[7] signipinnis)*	X[1,2,3]	X	--	--	--
Bluenose shiner (*Pteronotropis[7] welaka)*	X[1,3,5]	X[1,3,5]	--	X[1,3]	--
Creek chub (*Semotilus atromaculatus)*	X[1,2,3]	--	X[1,3,4,5,8]	--	X[1,3,4,5,8]
Dixie chub (*Semotilus thoreauianus)*	--	--	X	--	--
CATASTOMIDAE					
Quillback *(Carpiodes cyprinus)*	X[1,2,3,4]	X[1,3,4,5]	--	X[3]	--
White sucker *(Catostomus commersonii)*	--	--	X	--	--
Creek chubsucker *(Erimyzon oblongus)*	X[2]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Lake chubsucker *(Erimyzon sucetta)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4,5]	--
Alabama hog sucker (*Hypentelium etowanum)*	--	X[1,4,5,8]	X[1,4,5,8]	--	--
Spotted sucker (*Minytrema melanops)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Grayfin redhorse (*Moxostoma sp. cf. poecilurum)*	X[1,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Greater jumprock (*Scartomyzon[9] lachneri)*	--	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Striped jumprock (*Scartomyzon[9] rupiscartes)*	--	--	X[1,4,8]	--	X[3]
ICTALURIDAE					
Snail bullhead *(Ameiurus[10] brunneus)*	X	X	X	X	X
White catfish (*Ameiurus[10] catus)*	X	X	--	X	--
Black bullhead (*Ameiurus[10] melas)*	--	--	X	--	--
Yellow bullhead (*Ameiurus[10] natalis)*`	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Brown bullhead (*Ameiurus[10] nebulosus)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Spotted bullhead (*Ameiurus[10] serracanthus)*	X[1,2,3]	X[1,3,4]	--	X[1,3,4]	--

Common and *scientific* names	Apalachicola River Basin	Chattahoochee River Basin		Flint River Basin	
	Coastal Plain Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion
Channel catfish (*Ictalurus punctatus)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Tadpole madtom (*Noturus gyrinus)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Black madtom (*Noturus funebris)*	X[1,2,3]	--	--	--	--
Speckled madtom *(Noturus leptacanthus)*	X[1,2,3]	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Flathead catfish *(Pylodictis olivaris)*	X[2]	X[3,4,8]	X[3,4,8]	X[1,3,4]	X[1,3,4]
ESOCIDAE					
Redfin pickerel (*Esox americanus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Chain pickerel (*Esox niger)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]	X[1,3,4]
APHREDODERIDAE					
Pirate perch *(Aphredoderus sayanus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	--
BELONIDAE					
Atlantic needlefish (*Strongylura marina)*	X[1,2]	X[1,4,5]	--	--	--
FUNDULIDAE					
Golden topminnow *(Fundulus chrysotus)*	X[1,3,4]	--	--	X[1,3,4]	--
Banded topminnow *(Fundulus cingulatus)*[11]	X[1,2,3]	--	--	--	--
Eastern starhead *(Fundulus escambiae)*	X	--	--	X	--
Blackspotted topminnow *(Fundulus olivaceus)*	X[2]	X[1,3,4,5,8]	X[1,3,4,5,8]	--	--
Southern studfish (*Fundulus stellifer)*	--	X[1,3,4,8]	X[1,3,4,8]	--	--
Pygmy killifish *(Leptolucania ommata)*	X[1,2,3]	--	--	--	--
Bluefin killifish *(Lucania goodie)*	X[1,2,3]	--	--	--	--
POECILIIDAE					
Mosquitofish *Gambusia* sp. cf. *affinis)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Least killifish (*Heterandria formosa)*	X[1,2,3]	X[1,3]	--	X[1,3]	--
Sailfin molly (*Poecilia latipinna)*	X[3]	--	--	--	--
ATHERINIDAE					
Brook silverside *(Labidesthes sicculus)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--

Common and *scientific* names	Apalachicola River Basin	Chattahoochee River Basin		Flint River Basin	
	Coastal Plain Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion	Coastal Plain Ecoregion	Piedmont Ecoregion
COTTIDAE					
Mottled sculpin *(Cottus bairdi)*	--	--	X[1,3,4,8]	--	--
Banded sculpin *(Cottus carolinae)*	--	--	X[1,3,4,8]	--	--
MORONIDAE					
White bass *(Morone chrysops)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Striped bass *(Morone saxatilis)*	X[1,2,3]	X[1,3,4]	X[1,3,4]	X[1,3,4]	X[1,3,4]
Sunshine bass (*Morone chrysops X saxatilis)*	X[3]	X[3]	X[3]	X[3]	X[3]
ELASSOMATIDAE					
Everglades pygmy sun fish *(Elassoma everglade)*	X[1,2,3]	--	--	X[1,3,4]	--
Okefenokee pygmy sun fish *(Elassoma okefenokee)*	X[1,2,3]	--	--	--	--
Banded pygmy sunfish *(Elassoma zonatum)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
CENTRARCHIDAE					
Shadow bass *(Ambloplites ariommus)*	X[2]	X[1,3,4]	X[1,3,4]	X[1,3,4]	X[1,3,4]
Flier *(Centrarchus macropterus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	--
Bluespotted sunfish *(Enneacanthus obesus)*	X[1,2,3]	--	--	X[1,2,3]	--
Banded sunfish *(Enneacanthus auritus)*	X[1,2,3]	--	--	X[1,3,4]	--
Redbreast sunfish *(Lepomis auritus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Green sunfish *(Lepomis cyanellus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[3]	X[3]
Warmouth *(Lepomis gulosus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Orangespotted sunfish *(Lepomis humilis)*	X[1,2,3]	X[1,4,5]	--	X[3]	--
Bluegill *(Lepomis macrochirus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Dollar sunfish *(Lepomis marginatus)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
Longear sunfish *(Lepomis megalotis)*	X[3]	X[1,3,4,5]	X[1,3,4,5]	--	--
Redear sunfish *(Lepomis microlophus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Spotted sunfish intergrade *(Lepomis miniatus X L. punctatus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]

Common and *scientific* names	Apalachicola River Basin	Chattahoochee River Basin		Flint River Basin	
	Coastal Plain Ecoregion	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*	*Coastal Plain Ecoregion*	*Piedmont Ecoregion*
Redeye bass *(Micropterus coosae)*	--	X[1,3,4,5,8]	X[1,3,4,5,8]	X[1,3,4]	X[1,3,4]
Shoal bass *(Micropterus cataractae)*	X[1,2,3]	X[1,3,4]	X[1,3,4]	X[1,3,4]	X[1,3,4]
Smallmouth bass *(Micropterus dolomieu)*	--	X[1,3,4,5]	X[1,3,4,5]	--	--
Largemouth bass *(Micropterus salmoides)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
White crappie *(Pomoxis annularis)*	X[3]	X[1,3,4]	X[1,3,4]	X[1,3,4]	X[1,3,4]
Black crappie *(Pomoxis nigromaculatus)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
PERCIDAE					
Florida sand darter *(Ammocrypta bifascia)*	X[1,2,3]	--	--	--	--
Brown darter *(Etheostoma edwini)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
Swamp darter *(Etheostoma fusiforme)*	X[1,2,3]	X[1,3,4,5]	--	X[1,3,4]	--
Goldstripe darter *(Etheostoma parvipinne)*	X[2,3,4]	X[1,3,4,5]	--	X[1,3,4]	--
Gulf darter *(Etheostoma swaini)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Yellow perch *(Perca flavescens)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[3]	X[3]
Blackbanded darter *(Percina nigrofasciata)*	X[1,2,3]	X[1,3,4,5]	X[1,3,4,5]	X[1,3,4]	X[1,3,4]
Sauger *(Sander canadensis)*	X[1,2,3]	X[1,3,4]	X[1,3,4]	--	--
Walleye *(Sander vitreum)*	--	X[1,3,4]	X[1,3,4]	--	--
MUGILIDAE					
Mountain mullet *(Agonostomus monticola)*	X[1,2,3]	--	--	--	--
Striped mullet *(Mugil cephalus)*	X[2]	--	--	--	--
White mullet *(Mugil curema)*	X[1,2,3]	--	--	X[3]	--
SOLEIDAE					
Hogchoker *(Trinectes maculates)*	X[1,2,3]	X[4]	X[8]	X[4]	--

1. Yerger 1977; 2. Edmiston and Tuck 1987; 3. Barkuloo et al. 1987; 4. Dahlberg and Scott 1971; 5. Gilbert 1969; 6. Predominately found in Blue Ridge Province, but also stocked in upper Piedmont Province; 7. formerly *Notropis*, Mayden 1989; Page and Johnston 1990; 8. From Satterfield 1961; 9. *Scartomyzon* formerly *Moxostoma*, Jenkins and Burkhead 1993; 10. *Ameiurus* formerly *Ictalurus*, Lundberg 1992; 11. From Gilbert et al. 1992; 12. From USGS 2009; 13. From Maceina et al. 1999.

Table H-6.
Partial list of phytoplankton species documented in Apalachicola Bay (Livingston 1984)

Actinocyclus ehrenbergii	*Chaetoceros lorenzianus*	*Grammatophora marina*	*Pinnularia spp.*
Actinocyclus normanii f. subsala	*Chaetoceros pelagicus*	*Guirardia flaccida*	*Pleurosigma spp.*
Actinoptychus undulatus	*Chaetoceros peruvianus*	*Gyrosigma spp.*	*Proboscia alata*
Asterionella formosa	*Chaetoceros spp.*	*Hemiaulus hauckii*	*Protoperidinium grande*
Aulacoseira granulata	*Cocconeis disculoides*	*Licmophora abbreviata*	*Rhabdonema adriaticum*
Bacteriastrum delicatulum	*Coscinodiscus apiculatus*	*Lithodesmium undulatum*	*Rhizosolenia bergonii*
Bacteriastrum elongatum	*Coscinodiscus centralis*	*Melosira dubia*	*Rhizosolenia calcar-avis*
Bellerochea malleus	*Coscinodiscus concinnus*	*Melosira nummuloides*	*Rhizosolenia hebetata*
Biddulphia alternans	*Coscinodiscus excentricus*	*Melosira sulcata*	*Rhizosolenia imbricata*
Ceratium concilians	*Coscinodiscus marqinatus*	*Melosira varians*	*Rhizosolenia robusta*
Ceratium furca	*Coscinodiscus nitidus*	*Navicula lyra*	*Rhizosolenia setigera*
Ceratium fuses	*Coscinodiscus oculus-iridis*	*Navicula spp.*	*Rhizosolenia spp.*
Ceratium massiliense	*Coscinodiscus spp.*	*Nitzschia closterium*	*Rhizosolenia stolterfothii*
Ceratium trichoceros	*Coscinodiscus wailessii*	*Nitzschia paradoxa*	*Scenedesmus quadricauda*
Ceratium tripos	*Cymatosira belgica*	*Nitzschia pungens*	*Skeletonema costatum*
Chaetoceros affinis	*Cymbella tumida*	*Nitzschia sigmoidea*	*Surirella fastuosa*
Chaetoceros brevis	*Detonula pumila*	*Nitzschia spp.*	*Synedra spp.*
Chaetoceros coarctatus	*Diatoma spp.*	*Odontella aurita*	*Thalassionema nitzschioides*
Chaetoceros compressus	*Dinophysis caudate*	*Odontella longicruris*	*Thalassiothrix frauenfeldii*
Chaetoceros constrictus	*Dinophysis diegensis*	*Odontella rhombus*	*Thalassiothrix longissima*
Chaetoceros curvisetus	*Dinophysis tripos*	*Odontella sinensis*	*Thalassiothrix mediterranea*
Chaetoceros danicus	*Entomoneis paludosa*	*Pediastrum duplex*	*Triceratium favus*
Chaetoceros decipiens	*Eucampia cornuta*	*Pediastrum simplex*	*Triceratium reticulum*
Chaetoceros didymus	*Eupodiscus radiatus*	*Pediastrum tetras var. tetraodon*	
Chaetoceros glandazii	*Fragilaria spp.*	*Peridinium spp.*	

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Table H-7.
Partial list of fish species of the Apalachicola Bay Estuary (Livingston 1984, Edmiston 2008)

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
Acipenser oxyrinchus desotoi	Gulf sturgeon		X	X		X			X	
Adinia xenica	diamond killifish	X								
Agonostomus monticola	mountain mullet					X				
Alosa alabamae	Gulf or Alabama shad					X				
A. chrysochloris	skipjack herring					X				
Aluterus schoepfii	orange filefish			X						
Ameiurus catus	white catfish			X						
Ameiurus natalis	yellow bullhead	X								
Anchoa hepsetus	striped anchovy		X	X	X					
Anchoa mitchilli	bay anchovy	X	X	X	X					
Ancylopsetta ommata	ocellated flounder			X				X		
Anguilla rostrata	american eel	X				X				
Archosargus probatocephalus	sheepshead	X		X				X		
Ariopsis felis	hardhead catfish			X						
Astroscopus y-graecum	southern stargazer			X						
Atherinidae	silversides				X					
Bagre marinus	gafftopsail catfish			X						
Bairdiella chrysoura	silver perch	X	X	X	X					
Brevoortia patronus	Gulf menhaden	X		X	X					
Carangoides bartholomaei	yellow jack			X						
Caranx hippos	crevalle jack			X						
Centropristis striata	black sea bass			X						
Chaetodipterus faber	atlantic spadefish			X						
Chilomycterus schoepfii	striped burrfish			X						
Chloroscombrus chrysurus	atlantic bumper			X	X					
Ctenogobius boleosoma	darter goby			X						
Ctenopharyngodon idella	grass carp									X
Cynoscion arenarius	sand sea trout	X		X	X					
Cynoscion nebulosus	spotted seatrout		X	X	X			X		
Cyprinella callitaenia	bluestripe shiner						X			
Cyprinodon variegatus	sheepshead minnow	X								

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
Cyprinus carpio	common carp	X								X
Dasyatis sabina	Atlantic stingray			X						
Diplectrum formosum	sand perch			X						
Diplodus holbrookii	spottail pinfish			X						
Dorosoma petenense	threadfin shad			X						
Epinephelus sp.	grouper			X				X		
Etropus crossotus	fringed flounder			X				X		
Eucinostomus argenteus	spotfin mojarra			X						
Eucinostomus gula	silver jenny	X	X	X						
Fundulus confluentus	marsh killifish	X								
Fundulus grandis	Gulf killifish	X								
Fundulus similis	longnose killifish	X	X							
Gobiesox strumosus	skilletfish				X					
Gobionellus hastatus	darter goby			X						
Gobiosoma bosc	naked goby	X		X						
Gobiosoma sp.	naked goby				X					
Gymnura micrura	smooth butterfly ray			X						
Harengula jaguana	scaled sardine	X		X	X					
Hippocampus erectus	lined or spotted seahorse			X						
Hypleurochilus geminatus	crested blenny				X					
Hypsoblennius hentz	feather blenny			X	X					
Ictalurus furcatus	blue catfish									X
Lagodon rhomboides	pinfish		X	X	X					
Leiostomus xanthurus	spot		X	X	X					
Lepisosteus osseus	longnose gar	X								
Lepomis cyanellus	green sunfish							X		X
Lepomis humilis	orange-spotted sunfish									X
Lepomis microlophus	redear sunfish	X						X		
Lepomis punctatus	spotted sunfish	X								
Lobotes surinamensis	tripletail			X				X		
Lolliguncula brevis	atlantic brief squid									
Lucania goodei	bluefin killifish	X								
Lucania parva	rainwater killifish	X	X	X						
Lutjanus griseus	gray snapper	X		X						

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
Menidia beryllina	inland silverside	X	X	X						
Menticirrhus americanus	southern kingfish			X	X					
Menticirrhus saxatilis	northern kingfish or Gulf minkfish			X						
Microgobius gulosus	clown goby	X		X						
Microgobius thalassinus	green goby			X						
Micropogonias undulatus	Atlantic croaker	X		X	X			X		
Micropterus cataractae	shoal bass						X	X		
Micropterus punctulatus	spotted bass							X		X
Micropterus salmoides	largemouth bass	X						X		
Monacanthus ciliatus	fringed filefish			X						
Morone chrysops	white bass							X		X
Morone saxatilis	striped bass					X		X		X
Moxostoma n. sp. cf poecilurum	grayfin redhorse						X			
Mugil cephalus	black, gray, or striped mullet	X	X							
Mugil curema	silver or white mullet	X								
Mugil sp.	gray mullets			X						
Myrophis punctatus	speckled worm eel			X						
Notemigonus crysoleucas	golden shiner	X								
Notropis sp.	eastern shiners	X								
Notropis zonistius	bandfin shiner						X			
Ogilbia cayorum	key brotula			X						
Oligoplites saurus	leatherjack or leatherjacket			X						
Ophichthus gomesii	shrimp eel			X						
Ophidion holbrookii	longnose cusk-eel			X						
Opsanus beta	Gulf toad fish		X	X						
Orthopristis chrysoptera	pigfish		X	X						
Paralichthys albigutta	gulf flounder			X				X		
Paralichthys lethostigma	southern flounder	X		X				X		
Peprilus burti	Gulf butterfish			X						
Peprilus paru	northern harvestfish			X						
Perca flavescens	yellow perch							X		X
Poecilia latipinna	sailfin molly	X								
Polydactylus octonemus	Atlantic threadfin			X						

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
Polyodon spathula	American paddlefish									X
Pomatomus saltatrix	bluefish			X				X		
Pomoxis annularis	white crappie									X
Pomoxis nigromaculatus	black crappie	X						X		
Poqonias cromis	black drum				X			X		
Porichthys porosissimus	Atlantic midshipman			X						
Prionotus scitulus	leopard searobin			X						
Prionotus sp.	North American searobins				X					
Prionotus tribulus	bighead searobin			X						
Pylodictis olivaris	flathead catfish							X		X
Rachycentron canadum	cobia		X	X				X		
Rhinoptera bonasus	cownose ray			X						
Sander canadensis	sauger									X
Sardinella aurita	Spanish sardine or round sardinella			X						
Sciaenops ocellatus	red drum			X	X			X		
Scomberomorus cavalla	king mackerel			X				X		
Scomberomorus maculatus	Atlantic Spanish mackerel			X				X		
Selene vomer	lookdown			X						
Seriola sp.	amberjack			X				X		
Sphoeroides nephelus	southern puffer			X						
Sphyraena borealis	northern sennet			X						
Sphyrna tiburo	bonnethead			X						
Stellifer lanceolatus	star drum	X		X						
Stephanolepis hispida	planehead filefish			X						
Strongylura marina	Atlantic needlefish		X			X				
Symphurus plagiusa	blackcheek tonguefish			X						
Syngnathus floridae	dusky pipefish		X	X						
Syngnathus louisianae	chain pipefish			X	X					
Syngnathus scovelli	Gulf pipefish			X	X					
Synodus foetens	inshore lizardfish		X	X				X		
Trachinotus sp.	pompano			X						
Trinectes maculatus	hogchoker	X		X	X	X				
Urophycis floridana	southern codling or hake			X						

Table H-8.
A partial list of invertebrate taxa found in the Apalachicola Bay Estuary (Livingston 1984, Edmiston 2008)

Scientific name	Common name	Scientific name	Common name
Ablabesmyia sp.	non-biting midge	*Macoma balthica*	baltic macoma
Abra aequalis	atlantic abra	*M. mitchelli*	matagorda macoma
Acetes americanus	aviu shrimp	*Macrobrachium ohione*	ohio river shrimp
Acteocina canaliculata	channeled barrel-bubble	*Mactrotoma fragilis*	fragile surfclam
Alpheus armillatus	banded snapping shrimp	*Magelona polydentata*	polychaete
A. formosus	striped snapping shrimp	*Magelona sp.*	polychaete
A. heterochaelis	bigclaw snapping shrimp	*Marphysa sanguinea*	polychaete
A. normanni	green snapping shrimp	*Martesia smithi*	boring clam
Ambidexter symmetricus	night shrimp	*Mediomastus ambiseta*	polychaete
A. almyra	opossum shrimp	*Mediomastus sp.*	polychaete
A. bahia	opossum shrimp	*Melinna maculata*	polychaete
Ampelisca abdita	gammarid amphipod	*Melitta appendiculata*	gammarid amphipod
A. cristata microdentata	gammarid amphipod	*M. elongata*	gammarid amphipod
A. vadorum	gammarid amphipod	*M. fresnelii*	gammarid amphipod
A. verrilli	gammarid amphipod	*M. intermedia*	gammarid amphipod
Amphicteis floridus	polychaete	*M. longisetosa*	gammarid amphipod
A. gunneri	polychaete	*M. nitida*	gammarid amphipod
Amphinome rostrata	polychaete	*Melongena corona*	crown conch
Amygdalum papyrium	atlantic papermussel	*Menippe mercenaria*	Florida stone crab
Anachis avara	greedy dovesnail	*Metapenaeus intermedius*	middle shrimp
A. brasiliana	incongruous ark	*Metoporhaphis calcarata*	false arrow crab
A. transversa	transverse ark	*Microdeutopus sp.*	gammarid amphipod
Ancistrosyllis hartmanae	polychaete	*Microtendipes sp.*	non-biting midge
Ancistrosyllis sp.	polychaete	*Mitrella lunata*	lunar dovesnail
Aplysia brasiliana	sooty seahare	*Mnemiopsis sp.*	comb jelly
Arenicola cristata	polychaete	*Mulinia lateralis*	dwarf surfclam
Argulus sp.	crustacean	*Mytilopsis leucophaeta*	dark falsemussel
Aricidea fragilis	polychaete	*Nanocladius sp.*	non-biting midge
Armases cinereum	squareback marsh crab	*Neanthes succinea*	polychaete
Baetidae	mayfly	*Nemertea*	proboscis worms
Batea catharinensis	gammarid amphipod	*Neopanope packardii*	Florida grassflat crab
Beroe sp.	comb jelly	*Nereiphylla fragilis*	polychaete
Bezzia sp.	biting midge	*Neritina reclivata*	olive nerite
Bittium varium	grass cerith	*Notomastus hemipodus*	polychaete
Boonea impressa	impressed odostome	*Nudibranchia*	mollusk
Brachidontes exustus	scorched mussel	*Nymphula sp.*	moth
Brachidontes sp.	mollusk	*Odostomia laevigata*	mollusk
Branchioasychis americana	polychaete	*Ogyrides alphaerostris*	estuarine longeye shrimp
Bulla striata	striate bubble	*Ogyrides limicola*	longeye shrimps

Scientific name	Common name	Scientific name	Common name
Busycotypus spiratus	pearwhelk	*Olivella sp.*	mollusk
Caenis sp.	mayfly	*Onuphidae*	polychaete
Callibaetis sp.	mayfly	*Ophiodromus obscurus*	polychaete
Callinectes sapidus	blue crab	*Ophiothrix angulata*	angular brittle star
Cantharus cancellarius	mollusk	*Orchestia grillus*	gammarid amphipod
Capitella capitata	polychaete	*O. uhleri*	gammarid amphipod
Capitellides jonesi	polychaete	*Orthocladius sp.*	non-biting midge
Carazziella hobsonae	polychaete	*Ostrea equestris*	crested oyster
Carinobatea sp.	gammarid amphipod	*Ostracoda*	ostracod
Cassidinidea ovalis	isopod	*Ovalipes quadulpensis*	lady crab
Cerapus sp. (cf. tubularis)	gammarid amphipod	*Pagurus bonairensis*	right-handed hermit crabs
Chaetozone sp.	polychaete	*P. longicarpus*	long-armed hermit crab
Chironomus sp.	non-biting midge	*P. pollicaris*	flatclaw hermit
Chiton tuberculatus	West Indian green chiton	*Palaemon floridanus*	Florida grass shrimp
Chrysaora quinquecirrha	sea nettle	*Palaemonetes intermedius*	brackish grass shrimp
Cladotanytarsus sp.	non-biting midge	*P. pugio*	daggerblade grass shrimp
Clibanarius vittatus	thinstripe hermit	*Palaemonetes spp.*	shrimp
Clinotanypus sp.	non-biting midge	*P. vulgaris*	marsh grass shrimp/ common grass shrimp
Clymenella sp.	polychaete	*Panopeus herbstii*	atlantic mud crab
Coelotanypus sp.	non-biting midge	*Paracaprella tenuis*	skeleton shrimp
Corixidae	water boatman	*Parachironomus sp.*	non-biting midge
Corophium louisianum	gammarid amphipod	*Paranais litoralis*	oligochaete
C. simile	gammarid amphipod	*Paranaitis speciosa*	polychaete
Corophium sp.	gammarid amphipod	*Parandalia americana*	polychaete
Crangonyx richmondensis	bog crangonyctid	*P. tricuspis*	polychaete
Crassostrea virginica	eastern oyster	*Paraonis sp.*	polychaete
Crepidula fornicata	atlantic slippersnail	*Paraprionospio pinnata*	polychaete
C. plana	eastern white slippersnail	*Pectinaria gouldi*	polychaete
Crepidula sp.	slippersnail	*Peloscolex benedeni*	oligochaete
Cryptochironomus fulvus	non-biting midge	*P. heterochaetus*	oligochaete
Cryptochironomus sp.	non-biting midge	*Pentacta sp.*	pigmy sea cucumber
Cumacea sp.	crustacean	*Periclimenes americanus*	American grass shrimp
Cyathura polita	isopod	*P. longicaudatus*	longtail grass shrimp
Cyclaspis varians	crustacean	*Persephona mediterranea*	mottled purse crab
Cymadusa compta	amphipod	*Petrolisthes armatus*	green porcelain crab
Cymadusa sp.	amphipod	*Phallodrilus sp.*	oligochaete
Dicrotendipes sp.	non-biting midge	*Pionosyllis sp.*	polychaete
Dinocardium robustum	mollusk	*Podarke sp.*	polychaete
Diopatra cuprea	polychaete	*Podarkeopsis brevipalpa*	polychaete
Diplodonta semiaspera	pimpled diplodon	*Podochela riisei*	longfinger neck crab

Scientific name	Common name	Scientific name	Common name
Dipolydora socialis	polychaete	*Polinices duplicatus*	mollusk
Dyspanopeus texanus	Gulf grassflat crab	*Polydora ligni*	polychaete
Echinarachnius parma	sand dollar	*P. socialis*	polychaete
Echinaster sp.	starfish	*P. websteri*	polychaete
Edotia montosa	isopod	*Polymesoda caroliniana*	Carolina marshclam
Edotia sp. (cf. montosa)	isopod	*Polypedilum sp.*	non-biting midge
Ensis minor	minor jackknife clam	*Portunus gibbesii*	iridescent swimming crab
Epitonium rupicola	brown-band wentletrap	*Procambarus paeninsulanus*	crayfish
Erichsonella sp. (cf. filiformis)	isopod	*Processa fimbriata*	grass night shrimp
Erichthonius sp.	gammarid amphipod	*P. hemphilli*	night shrimp
E. brasiliensis	gammarid amphipod	*Processa sp.*	night shrimp
Eteone heteropoda	polychaete	*Procladius sp.*	non-biting midge
Eupleura sulcidentata	sharp-rib drill	*Prunum apicinum*	common atlantic marginella
Eurypanopeus depressus	flatback mud crab	*Pseudocyrena floridana*	Florida marsh clam
Fabricia sp.	polychaete	*Rangia cuneata*	Atlantic rangia
Farfantepenaeus aztecus	brown shrimp	*Rhithropanopeus harrislii*	estuarine mud crab
F. duorarum	pink shrimp/northern pink shrimp	*Scolelepis texana*	polychaete
Fasciolaria tulipa	true tulip	*Scoloplos rubra*	polychaete
Gammarus lecroyae	gammarid amphipod	*Sicyonia brevirostris*	hardback shrimp
G. mucronatus	gammarid amphipod	*S. dorsalis*	lesser rock shrimp
Gammarus sp.	gammarid amphipod	*Sigambra bassi*	polychaete
Gilvossius setimanus	ghost shrimps	*Sphaeroma terebrans*	mangrove boring isopod
Gitanopsis spp.	gammarid amphipod	*Spiophanes bombyx*	polychaete
Glycera americana	polychaete	*Squilla empusa*	squillid mantis shrimps
Glycinde solitaria	polychaete	*Steninonereis martini*	polychaete
Glyptotendipes sp.	non-biting midge	*Stomolophus meleagris*	cabbagehead jellyfish
Grandidierella bonnieroides	gammarid amphipod	*Stramonita haemastoma*	Florida rocksnail
Grandidierella sp.	gammarid amphipod	*Streblospio benedicti*	polychaete
Haploscoloplos foliosus	polychaete	*Syllides sp.*	polychaete
H. fragilis	polychaete	*Tagelus plebeius*	stout tagelus
Hargeria rapax	crustacean	*Tanypus sp.*	non-biting midge
Harnischia sp.	non-biting midge	*Tanytarsus sp.*	non-biting midge
Haustoriidae	gammarid amphipod	*Taphromysis bowmani*	opossum shrimp
Hemipholis elongata	brittle star	*T. louisianae*	opossum shrimp
Heteromastus filiformis	polychaete	*Tellina texana*	Texas tellin
Hexapanopeus angustifrons	smooth mud crab	*Texadina sphinctostoma*	narrowmouth hydrobe
Hippolyte zostericola	zostera shrimp	*Thais haemastoma*	southern oyster drill
Ischadium recurvum	hooked mussel	*Thor dobkini*	squat grass shrimp
Kalliapseudes sp.	crustacean	*Tozeuma carolinense*	arrow shrimp
Laeonereis culveri	polychaete	*Trachypenaeus constrictus*	roughneck shrimp

Scientific name	Common name	Scientific name	Common name
Leander tenuicornis	brown grass shrimp	*T. similis*	roughback shrimp
Lembos sp.	gammarid amphipod	*Tubificoides sp.*	oligochaete
Lepidactylus sp.	gammarid amphipod	*Tubulanus sp.*	proboscis worm
Lepidophthalmus jamaicense	ghost shrimps	*Uca minax*	redjointed fiddler
Libinia dubia	longnose spider crab	*Uromunna reynoldsi*	isopod
L. emarginata	portly spider crab	*Urosalpinx perrugata*	Gulf oyster drill
Limnodriloides sp.	oligochaete	*Xenanthura brevitelson*	isopod
Litopenaeus setiferus	northern white shrimp	*Xiphopenaeus kroyeri*	Atlantic seabob
Littoridina sp.	mollusk		
Lolliguncula brevis	Atlantic brief squid		
Luidia clathrata	lined sea star		
Lumbrineris tenuis	polychaete		
Lysmata wurdemanni	peppermint shrimp		

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Appendix I

Record of Non-Applicability

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RECORD OF NON-APPLICABILITY

In Accordance with the Clean Air Act—General Conformity Rule for the Master Water Control Manual Updates for the Apalachicola – Chattahoochee – Flint River Basin

The Army Corp of Engineers proposes to update the Master Water Control Manual that outlines water management operations throughout the Apalachicola-Chattahoochee-Flint River Basin. Water Control Manuals outline the regulation schedules for each project and specifications for storage and releases from each reservoir. Water Control Manuals outline policies and data protocols for flood control operations and drought contingency operations. The updates to the water control manual are not expected to result in any reasonably foreseeable direct or indirect emissions. These types of federal activities are specifically exempt from the general conformity regulations.

General Conformity under the Clean Air Act, Section 176 has been evaluated according to the requirements of Title 40 of the *Code of Federal Regulations* Part 93, Subpart B. The requirements of this rule are not applicable to the proposed action or the alternatives because:

> The proposed activities would result would result in no emissions increase (40 CFR 93.153(c) (2)), and/or the emissions are not reasonably foreseeable, such as electric power marketing activities that involve the acquisition, sale and transmission of electric energy (40 CFR 93.153(c)(3) (ii)).

Supported documentation and emission estimates:

( ) Are Attached

( ) Appear in the NEPA Documentation

(X) Other (Not Necessary)

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