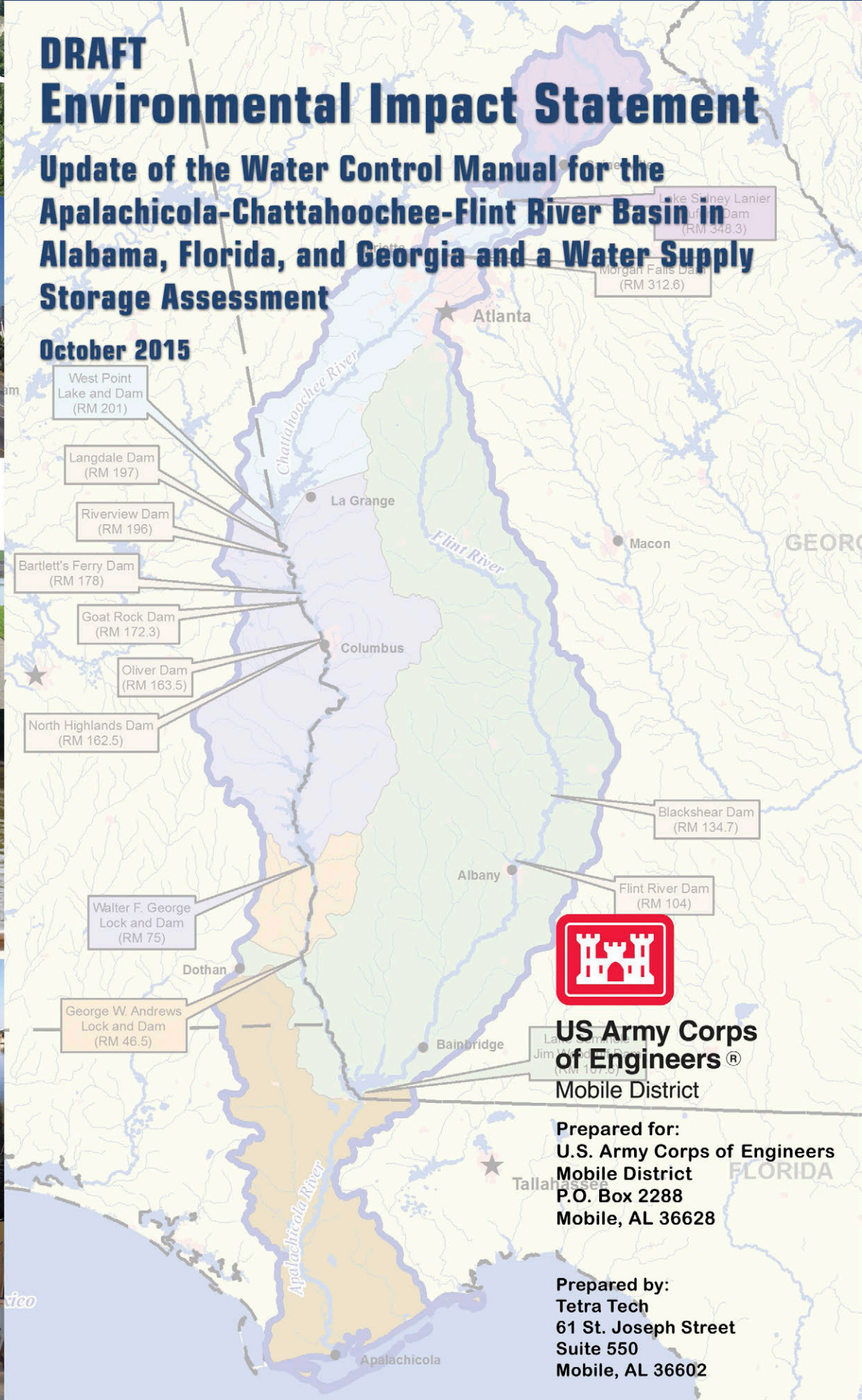




DRAFT Environmental Impact Statement

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

October 2015



US Army Corps of Engineers®
Mobile District

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

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

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Appendix B

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Water Supply Storage Assessment Report

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Apalachicola Chattahoochee Flint Water Supply Storage Assessment

An Evaluation of Water Supply Storage
from Lake Lanier

U.S. Army Corps of Engineers
October 2015

APALACHICOLA-CHATTAHOOCHEE-FLINT (ACF) WATER SUPPLY STORAGE ASSESSMENT

An Evaluation of Water Supply Storage from Lake Lanier

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1 **Executive Summary**

2 This water supply storage assessment was prepared in response to requests for water
3 supply storage in Lake Lanier by the State of Georgia on May 16, 2000. By letter dated
4 January 11, 2013, the State of Georgia provided updated information and data relevant
5 to the 2000 request. Following a 2011 court decision, the U.S. Army Corps of
6 Engineers (USACE) reconsidered the applicable legal authorities and concluded that it
7 has the legal authority to accommodate Georgia’s request, subject to further analysis
8 and evaluation of environmental impacts. The ACF WCM Environmental Impact
9 Statement and the Water Supply Storage Assessment in this appendix provide the
10 additional information necessary for the USACE to determine whether and to what
11 extent to accommodate Georgia’s water supply request.

12 The Proposed Action Alternative, which meets a gross need of 225 million gallons per
13 day (mgd), including a reallocation of 189,497 acre-feet (ac-ft) of storage equivalent to
14 165 mgd, is evaluated for financial feasibility in this assessment.¹ Various water supply
15 volumes from Lake Lanier underwent full impacts analysis in the Environmental Impact
16 Statement (EIS). A full range of water supply options were considered in this
17 assessment.

18 Construction of Lake Lanier began in 1950 and was completed in 1957 (reservoir did
19 not completely fill until 1959) by the USACE for the authorized purposes of flood control
20 (now referred to as flood risk management), water supply, hydroelectric power,
21 navigation, fish and wildlife conservation, and recreation. Two water withdrawal
22 contracts were authorized as part of the original project, 2 mgd for the City of Buford
23 and 8² mgd for the City of Gainesville, as compensation to property owners (the Cities
24 of Buford and Gainesville) for the taking of property associated with construction of
25 Buford Dam (Lake Lanier). Both cities had existing intake structures and water
26 treatment plants on riparian lands prior to commencement of project construction.
27 Under relocation agreements, the cities were allowed to relocate their existing water
28 supply intakes and continue to withdraw water from Lake Lanier.

29 This assessment also addresses the current and future water supply needs for current
30 and future users of Lake Lanier in the State of Georgia. It evaluates various measures
31 to provide the water specified in Georgia’s request, including reallocation from the

¹ From ER 1105-2-100 Appendix E page E -203. "The conceptual basis for evaluating the benefits from municipal and industrial water supply is society’s willingness to pay for the increase in the value of goods and services attributable to the water supply. Where the price of water reflects its marginal cost, that price is used to calculate willingness to pay for additional water supply. In the absence of such direct measures of marginal willingness to pay, the benefits from a water supply plan are measured instead by the resource cost of the alternative most likely to be implemented in the absence of that plan."

² Presently, Gainesville withdraws 18 mgd and returns 10 mgd resulting in a net withdrawal of 8 mgd. The total gross withdrawal under relocation contracts is 20 mgd.

1 conservation storage. Reallocation from the conservation storage was found to be
2 economically viable and was evaluated through full environmental impacts analysis.

3 A full impacts analysis was conducted on nine water supply and water management
4 scenarios. The impacts are presented in Chapter 6 of the EIS.

5 When a portion of conservation storage is allocated to accommodate water supply
6 withdrawals, other authorized purposes, in particular hydropower generation, may be
7 affected. The effects on other authorized purposes for certain water supply alternatives
8 have been analyzed and are set forth in this WSSA and the EIS.”).

9 For the reallocation of 189,497 ac-ft of storage, the average annual cost, which is the
10 updated cost of storage, evaluated over a 50-year economic evaluation period and the
11 Fiscal Year (FY) 2015 discount³ rate of 3.375 percent, would be \$2,053,000.

12 Average annual water supply benefits for the reallocation of 189,497 ac-ft of storage
13 (about 165 mgd), evaluated over a 50-year economic evaluation period and a discount
14 rate of 3.375 percent, would be \$51,150,000 (including operations and maintenance
15 (O&M)). This value is based on cost most likely alternative with the least cost that
16 would be implemented in the absence of reallocation from Lake Lanier.

17 To test the financial feasibility of storage reallocation from Lake Lanier, the annual cost
18 of the proposed reallocated storage was compared to the annual cost of the most likely,
19 least costly, water supply source that would provide an equivalent quality and quantity
20 of water if storage reallocation at Lake Lanier were not an option for the State of
21 Georgia. The proposed Chattahoochee River Withdrawal and Pumping scenario was
22 found to be the most likely and least costly water supply alternative to Lake Lanier
23 storage reallocation. The proposed Chattahoochee River Withdrawal and Pumping
24 scenario would pump water from downstream of Lanier, treat the water for supply,
25 distribute to users, and release it into Lake Lanier. The construction would involve
26 building an infrastructure of piping and pumping stations to tie in with the existing
27 distribution network. The proposed Chattahoochee River Withdrawal and Pumping
28 scenario can supply about 165 mgd for the State of Georgia and would have an
29 estimated average annual cost of about \$51,150,000. The reallocation of storage in
30 Lake Lanier, with an average annual cost of \$2,053,000 passes the test of financial
31 feasibility by a factor of more than 24 to 1.

32 USACE regulations require that the cost of storage allocated to the non-Federal
33 sponsor will normally be established as the highest of four pricing methods: benefits or
34 revenues foregone, replacement cost, or updated cost of storage in the Federal project.
35 The pricing method applicable to the water supply storage allocated to the State of

³ Discount rate may change each fiscal year based on Economic Guidance issued by Headquarters USACE. The terms discount rate and interest rate may be used interchangeably.

1 Georgia is the “updated cost of storage”. The updated cost of reallocated storage is
2 estimated by updating the cost of the joint use features from the midpoint of
3 construction to the FY in which the reallocation of storage is approved. The updated
4 cost of the joint use features is then multiplied by the proportion of useable storage that
5 is to be reallocated to estimate the value of the reallocated storage.

6 The value of the 189,497 ac-ft of storage proposed for reallocation is calculated to be
7 \$45,430,000 based on updated cost of storage for FY2017. The annual value would be
8 \$2,470,000 based on a 30-year repayment period with an interest rate of 3.375 percent.
9 Using a 5-year average for OMRR&R expenses for Fiscal Years 2010-2014, the
10 estimated annual operation and maintenance cost would be about \$160,000. The total
11 annual payment during the 30-year repayment period would be \$2,630,000. An annual
12 payment for OMRR&R would continue to be made by the State of Georgia following the
13 30-year storage repayment period.

1.0 Purpose

On May 16, 2000, the Governor of the State of Georgia submitted a formal request to the Assistant Secretary of the Army (Civil Works) (ASA(CW)) to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta over the next 30 years, culminating in total, gross withdrawals of 705 million gallons per day (mgd), 297 mgd from Lake Lanier and 408 mgd downstream, by the year 2030. The Assistant Secretary of the Army (Civil Works) in 2002 denied Georgia's request concluding that a reallocation of conservation storage in Lake Lanier sufficient to accommodate the requested withdrawals would exceed the Secretary's authority. The 2011 decision of the 11th Circuit Court of Appeals, discussed in more detail in Section 3.5.2.8.2 of the EIS, set aside the Army's 2002 decision to deny Georgia's request and ordered the USACE to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request.

The 11th Circuit Court remanded the case to the district court with instructions to remand to the USACE for further proceedings "not inconsistent with this order." On October 5, 2011, the district court remanded the matter to the USACE in accordance with the appeals court's instructions to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request, in light of the legal authority conferred by Congress in the River and Harbor Act of 1946, P.L. No. 84-841 (July 30, 1956) (1956 Act), and the Water Supply Act of 1958.

In June 2012, the USACE submitted a Legal Opinion to the 11th Circuit Court, incorporated by reference (Memorandum for the Chief of Engineers, Subject: Authority to Provide for Municipal and Industrial Water Supply from the Buford Dam/Lake Lanier Project, Georgia dated 25 June 2012 (http://www.sam.usace.army.mil/Portals/46/docs/planning_environmental/acf/docs/2012_ACF_legalopinion.pdf) stating "the Corps has the legal authority to accommodate Georgia's request to withdraw 297 mgd from Lake Lanier, if return flows of 107 mgd are provided, and to make releases from Buford Dam to ensure minimum flows of 1381 cubic feet per second (cfs) downstream at Atlanta, enabling downstream withdrawals of 408 mgd, by the year 2030." The legal opinion further concluded that the USACE has sufficient authority under applicable law to accommodate Georgia's 2000 request, but noted that any decision to take action on Georgia's request would require further study.

On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 mgd to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request

1 (hereafter referred to as Georgia's 2013 request). This letter request and supplemental
2 documentation is contained in Appendix A to the assessment.

3 This water supply storage assessment adopts the 2012 Legal Opinion analysis of the
4 USACE's authority to provide water supply at Lake Lanier. This assessment will
5 recommend what amount of storage, if any, that should be reallocated from
6 conservation storage to water supply to meet Georgia's 2013 request. Additionally, if
7 reallocation of storage is recommended, this assessment will identify the cost of the
8 reallocated storage along with economic impacts; environmental impacts are discussed
9 in the EIS and its associated appendices.

10 **1.1 Authority**

11 The national policy of the United States regarding water supply, as defined by
12 Congress, has been developed over a number of years and is still being clarified and
13 extended by legislation. This policy is based on recognition that states and non-Federal
14 entities have the primary responsibility in the development and management of their
15 water supplies⁴.

16 **1.1.1 Public Law No. 84-841 "1956 Act"**

17 *Public Law 84-841*, enacted July 30, 1956 (1956 Act), granted USACE authority to enter
18 into an agreement with Gwinnett County, Georgia, for the allocation of 11,200 ac-ft of
19 storage for regulated water supply. Any water supply storage volumes evaluated in this
20 assessment will be considered for reallocation solely under the Water Supply Act of
21 1958 described below.

22 **1.1.2 Water Supply Act of 1958**

23 Reallocation is the reassignment of the use of existing storage space in a reservoir
24 project from one purpose to another. Authority for the USACE to reallocate existing
25 storage space to municipal and industrial (M&I) water supply is contained in Public Law
26 85-500, Title III, Water Supply Act of 1958, as amended, codified at (43 U.S.C. § 390b).
27 Section 390b(b), of this Act states ". . . it is hereby provided that storage may be
28 included in any reservoir project surveyed, planned, constructed or to be surveyed,
29 planned, and/or constructed . . . to impound water for present or anticipated future
30 demand or need for municipal and industrial water supply." Section 390b(e) of the Act
31 states "[M]odifications of a reservoir project theretofore authorized, surveyed, planned,
32 or constructed to include storage as provided in subsection (b), which would seriously
33 affect the purposes for which the project was authorized, surveyed, planned, or
34 constructed, or which would involve major structural or operational changes, will be
35 made only upon the approval of Congress as now provided by law." (USACE, 1998)

⁴ ER-1105-2-100 Appendix E pg. E-200.

2.0 Project Background

2.1 Authorization and Construction

Lake Lanier (Buford Dam), Georgia, was authorized by the River and Harbor Act approved July 1946 for the purposes of flood control (now referred to as flood risk management), fish and wildlife conservation, recreation, navigation, and water supply, and hydropower. Construction for Lake Lanier began in 1950. The project became operational in 1957 and achieved full pool in May of 1959.

2.1.1 Reservoir Description

Lake Lanier has a storage capacity (at the top of conservation pool - elevation 1,071 feet (ft)) of 1,955,200 ac-ft. Of that, 1,087,600 ac-ft is conservation storage and 867,600 ac-ft is inactive storage (Figure 1). 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, 598,800 ac-ft is reserved for flood storage between elevation 1,071 and 1,085. Total usable storage (the volume of water between the outlet works and the spillway crest) includes conservation storage plus flood storage (1,686,400 ac-ft). Lake Lanier has a surface area of 38,542 acres at elevation 1,071 ft.

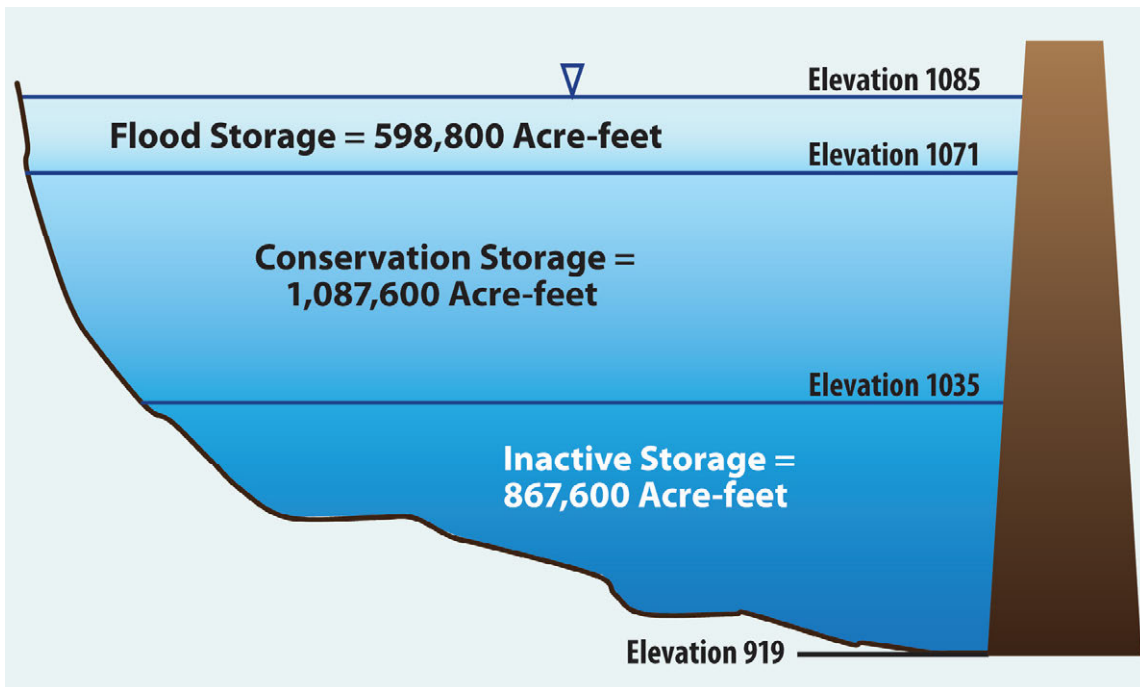


Figure 1. Buford Storage Capacity

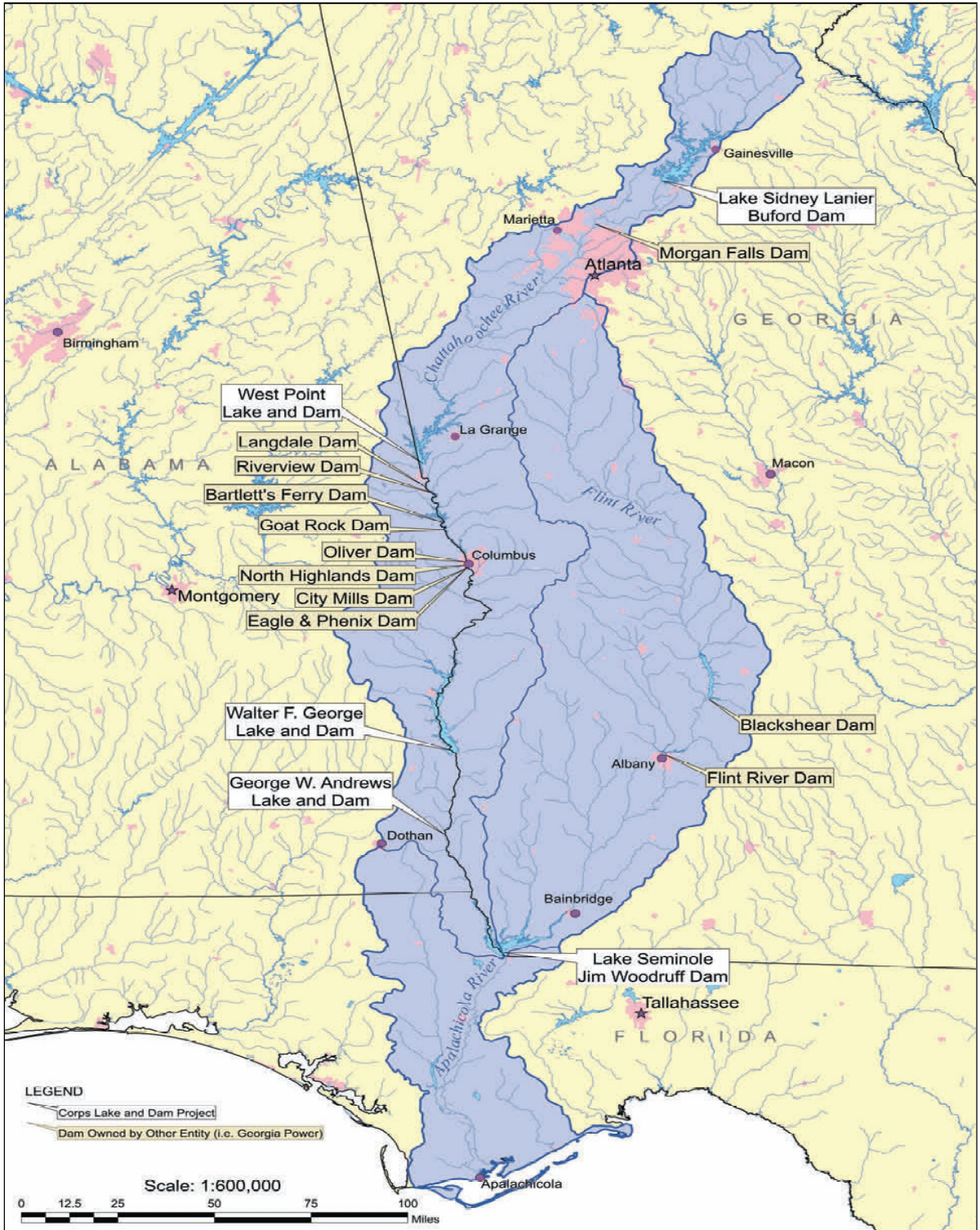
2.2 Study Area

The study area is the area within which significant project impacts will accrue from the use of M&I water supplies, including areas that will receive direct benefits and/or incur

1 costs from the provision of M&I water supply per ER 1105-2-100 Appendix E pg. E-205.
2 The water supply needs analysis is limited to the Atlanta/Lake Lanier region which was
3 part of the Georgia's 2013 request. Any reallocation of storage would be expected to
4 have system wide effects, which the USACE must take into account. Therefore, the
5 study area will encompass the entire ACF Basin.

6 The Chattahoochee River originates in the Blue Ridge Mountains of north Georgia, near
7 the westernmost tip of South Carolina, and extends to the southwest corner of the state.
8 The Chattahoochee River covers a distance of 434 miles from the Blue Ridge
9 Mountains to Lake Seminole. It flows out of the mountains, past Metro Atlanta, and
10 reaches the Georgia-Alabama border, at which point it forms the border between the
11 two states. From there, the Chattahoochee River flows south to its confluence with the
12 Flint River at Lake Seminole and then into the Apalachicola River.

13 The largest metropolitan area in the basin is Atlanta, Georgia, located in the northern
14 section. Progressing downstream are the Cities of Columbus, Georgia and Phenix City,
15 Alabama. Albany, Georgia is located in the eastern portion of the basin. At the Gulf of
16 Mexico is the City of Apalachicola, Florida.



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Figure 2. ACF WSSA Study Area

1 **3.0 Problems and Needs**

2 Georgia’s 2013 request stated that 3.3 million Georgians now rely on withdrawals or
 3 releases from Lake Lanier for water supply and that by 2040 approximately six million
 4 people will rely on Lake Lanier for water supply. That request projected a need for 705
 5 mgd that would be met by Lake Lanier either through releases for downstream
 6 consumption (408 mgd) or from direct withdrawals from the lake (297 mgd). Based on
 7 the legal analysis the downstream needs can be met as part of the authorized project
 8 purpose and does not require a water supply storage agreement. The analysis in the
 9 water supply storage assessment, therefore assumes that releases from Buford Dam
 10 sufficient to satisfy that demand would be met.

11 **3.1 Current and Future Lake Users**

12 Water supply providers currently withdrawing from Lake Lanier include the City of
 13 Buford, City of Cumming, Forsyth County, City of Gainesville, and Gwinnett County.
 14 Water withdrawals from by these entities in 2000 – 2011 are displayed in Table 1 below.
 15 The greatest demand for water in the ACF System as a whole occurred in 2007. In
 16 2007, the average water withdrawn directly from Lake Lanier was 128 mgd. In addition
 17 to the entities listed above that currently withdrawal from Lake Lanier, Georgia’s 2013
 18 request indicated that Habersham, White, Lumpkin, and Dawson Counties will also be
 19 likely future users of Lake Lanier. Withdrawals shown in Table 1 include those
 20 authorized under relocation agreements (Buford and Gainesville).

21 **Table 1. Lanier Annual Direct Water Withdrawals 2000-2011**

	Direct Water Withdrawals (mgd)											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Buford	1.37	1.24	1.29	1.40	1.43	1.44	1.53	1.47	1.31	1.22	1.27	1.29
Cumming	11.58	12.35	10.34	10.80	11.16	10.51	11.95	11.65	10.93	10.92	11.42	11.58
Forsyth County	3.38	3.60	5.42	4.12	5.70	6.50	6.83	8.44	4.90	6.26	7.78	8.63
Gainesville	18.27	17.50	17.32	16.85	17.73	17.87	19.00	18.76	16.37	16.65	17.53	17.66
Gwinnett County	85.13	85.73	83.67	76.37	84.39	83.58	92.67	88.27	73.59	72.77	75.52	76.19
Total	119.73	120.42	118.03	109.54	120.41	119.91	131.98	128.58	107.09	107.81	113.51	115.34

22 Source: USACE. 2014

23 Water supply demand has been projected for the Atlanta metro area in the Metropolitan
 24 North Georgia Water Planning District (MNGWPD) Water Supply, and Conservation
 25 Management Plan. Forecasts were made through 2035 and 2050. These forecasts did
 26 not include Habersham, White, Dawson, and Lumpkin Counties which, based on
 27 Georgia’s 2013 request, have a need of 41 mgd. Together with the MNGWPD
 28 forecasts, the total need identified through 2040 was 297 mgd which could be met by

1 withdrawals from Lake Lanier. A supplemental water demand forecast was completed
 2 by USACE to verify the stated needs provided in the Georgia 2013 request. The
 3 USACE forecast is discussed in Section 3.3 Water Demand Analysis.

4 **3.2 Current and Future Downstream needs from Lake Lanier**

5 Water withdrawals by Metro Atlanta water supply providers occurring downstream of
 6 Buford from 2000 – 2011 are displayed in Table 2 below. As stated previously, 2007
 7 represented the greatest demand for water in the ACF System as a whole. In 2007, the
 8 average water withdrawn from the Chattahoochee River was 275 mgd. MNGWPD also
 9 projected water supply demand for the Metro Atlanta area through 2035 and 2050.
 10 River withdrawals by the Metro Atlanta water supply providers are expected to increase
 11 from 275 mgd to 408 mgd by 2040.

12 Georgia’s 2013 request identified a need to withdraw 408 mgd from the Chattahoochee
 13 River between Buford Dam and the confluence of the Chattahoochee River and
 14 Peachtree Creek by 2040. Based on the 2012 Legal Opinion discussed above,
 15 releases from Buford Dam to provide for withdrawal of 408 mgd are authorized by the
 16 River and Harbor Act of 1946. Accordingly, analyses of potential reallocation will take
 17 into account that authorized withdrawals will be made by Metro Atlanta water supply
 18 providers in the amount of either 277 mgd (current need) or 408 mgd (future need).

19 **Table 2. Downstream Annual Metro Atlanta Water Withdrawals 2000-2011**

	Withdrawals from Chattahoochee River (mgd)											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
City of Atlanta	106.83	101.93	101.17	95.47	96.61	100.47	102.54	100.90	87.78	82.31	84.10	89.17
Atlanta-Fulton Co. Water Res. Commission	42.62	43.90	43.39	40.12	40.99	42.80	43.76	44.07	36.07	37.09	40.15	38.67
DeKalb County Public Works	94.18	87.89	87.38	82.23	83.98	83.05	82.81	78.36	72.58	73.85	74.95	72.68
Cobb County Marietta Water Authority	47.04	42.93	43.45	41.73	46.85	46.95	51.00	52.14	43.69	43.57	43.28	45.12
Total	291	277	275	260	268	273	280	275⁵	240	237	242	246

20 Source: USACE 2015

21 Analyses of water supply options discussed below were accomplished using ResSim
 22 modeling and 2007 withdrawals basinwide were used to reflect the No Action

⁵ In the RESSIM model, 277mgd was used as the gross river withdrawal value for 2007. 277 mgd was a carryover value from when modeling originally began and is representative of current river withdrawals.

1 Alternative as discussed in Sections 5 and 6 in the EIS. Modeling of other water supply
2 options considered changes in withdrawals either from Lake Lanier or from the
3 Chattahoochee River, or both while all other withdrawals throughout the basin were held
4 at 2007 levels.

5 **3.3 Water Supply Demand Analysis**

6 The purpose of this water supply demand analysis is to assist in making an informed
7 independent estimate regarding future water supply demand in order to determine
8 whether it would be in the public interest to reallocate storage to water supply. A
9 secondary purpose it to determine the reasonableness of Georgia's stated water need
10 from Lake Lanier. Water demand has been forecasted at the county-level in an effort to
11 provide useful information on trends in current and future water use. The forecast
12 begins with baseline demands (2010⁶) and projects these demands through the year
13 2070 in 10-year increments using a computational "driver times rate of use" approach.
14 This approach multiplies a water use factor by the projected number of future users to
15 estimate future water demands. A water demand forecast model tool was developed
16 based on 2010 United States Geological Survey county level sector production data,
17 demographic data, socioeconomic data, and historical agricultural data. The basic
18 methodology of the water demand model is to estimate water demand separately for
19 each water use category, also referred to as a water use sector. The methodology
20 selected to forecast water demand for each sector is determined by data availability.
21 This is the case for all sectors of this report. The sectors determined to be relevant to
22 the study area are listed below.

23 Sectors:

- 24 1. Domestic
- 25 2. Non-Residential
- 26 3. Irrigation-Crops
- 27 4. Irrigation-Golf
- 28 5. Agriculture-Livestock
- 29 6. Aquaculture

30 For each sector, the basic methodology for estimating water demand is to calculate a
31 product of the driver and the rate of use. The driver is defined as a countable unit
32 driving water demands up and down, which can be projected in future years, such as
33 population or number of households, number of acres irrigated, number of employees in
34 a business, etc. The rate of use is defined as the quantity of water used by the driving

⁶ 2010 is the latest year for which data was available. USGS typically publishes data in 5 year intervals.

1 unit, such as gallons per person per day, gallons per household, or acre-feet per
2 irrigated acre.

3 Based on the 2010 USGS data mentioned above, the residential sector portion of the
4 projection model was developed using a per capita water demand forecast. The non-
5 residential and agricultural portions of the forecast were developed utilizing a unit use
6 approach to estimate future demands. The per unit water use rate, or water use factor,
7 can be developed for most sectors given historical or current water use data and a
8 defined demographic unit. Projection of future water demand then requires having
9 projected values of the defined demographic unit. With this approach, the water use
10 factor of each sector can be assumed to either remain constant into the future,
11 decrease over time due to increases in water use efficiency, or increase over time due
12 to more intensive water use.

13 The county-level water demand forecasts presented in this report are contingent upon
14 a number of assumptions. These assumptions include the following:

- 15 • Residential water use in each county will maintain the current average rate of
16 water use per capita (weighted average of 87 mgd based on 2010 USGS
17 data).
- 18 • Self-supplied residential water use in 2010 was 75 gallons per day (GPD) for
19 the entire study area.
- 20 • The ratio of self-supplied population to system-served population for each
21 county will remain constant into the future at current levels.
- 22 • Future employment growth for each county will maintain the current
23 proportion by North American Industrial Classification System (NAICS)
24 classifications.
- 25 • Water use per employee into the future will maintain the current average rate
26 of use per employee per NAICS group.
- 27 • Water use for livestock will remain at current levels per animal.
- 28 • Water use per crop type will remain at current levels per acre.
- 29 • Water use efficiency and irrigation type by county will remain at current levels.
- 30 • Weather conditions are not addressed in this study.
- 31 • System losses among public and rural water district systems are not
32 accounted for in this study.
- 33 • The rates of water use per unit for each sector do not account for future
34 improvements in water use efficiency (i.e., water conservation).

35 All population forecasts are based on growth rates produced by the Georgia Office of
36 Planning and Budget March 12, 2010 report (2010-2030), the average forecasted

1 growth rates for the seven-county study area ranged from 2.0 percent – 3.9 percent.
 2 The population forecast for this report used a low, medium, and high scenario. The
 3 medium growth forecast is displayed in Table 3.

4 **Table 3. Medium Annual Growth (2.9 percent) Population Forecast**

	2	2	2	2	2	2	2
	0	0	0	0	0	0	0
	1	2	3	4	5	6	7
County	0	0	0	0	0	0	0
Publicly Supplied							
Dawson	16,370	21,787	28,997	38,593	51,365	68,362	90,985
Forsyth	173,290	230,636	306,959	408,540	543,737	723,673	963,155
Gwinnett	700,510	932,327	1,240,857	1,651,489	2,198,008	2,925,385	3,893,470
Habersham	27,670	36,827	49,014	65,233	86,821	115,552	153,791
Hall	151,820	202,061	268,928	357,924	476,370	634,012	843,823
Lumpkin	10,320	13,735	18,280	24,330	32,381	43,097	57,359
White	14,000	18,633	24,799	33,006	43,928	58,465	77,813
Self -Supplied							
Dawson	5,960	7,932	10,557	14,051	18,701	24,889	33,126
Forsyth	2,221	2,956	3,934	5,236	6,969	9,275	12,344
Gwinnett	104,811	139,496	185,658	247,097	328,868	437,699	582,545
Hall	27,864	37,085	49,357	65,691	87,430	116,362	154,870
Habersham	15,371	20,458	27,228	36,238	48,230	64,191	85,433
Lumpkin	19,646	26,147	34,800	46,316	61,644	82,043	109,193
White	13,144	17,494	23,283	30,988	41,242	54,890	73,055

5 **3.3.1 Residential (Domestic)**

6 All data for the residential sector of this study, which includes indoor use such as
 7 bathing, toilet flushing, clothes washing, dish washing, and other appliances, and
 8 outdoor uses such as lawn irrigation and car washing, was collected from USGS county
 9 level report (2010 Preliminary Report). Data was reported as total withdrawals from
 10 ground water and surface water sources. The data included breakouts of population
 11 receiving water either from the ground source or surface source (public supply). From
 12 this data the per capita use per day was determined. The remaining population, once
 13 public supply was removed from total population is assumed to be self-supplied.
 14 Residential growth scenarios are displayed in Tables 4 and 5. Table 5 shows public
 15 supply only.

- 1 • Per Capita Use Determination:
- 2 • Population Served by Public Supply (Surface +Groundwater)-Total Population
- 3 =Domestic Users
- 4 • Domestic Per Capita use: Total Domestic Water Use/Domestic Users. (GPD)
- 5 • Total Population-Population served by Public Supply =Self Supplied Users
- 6 • Self-Supplied Water Usage: Self-Supplied water use in 2010 averaged 75
- 7 GPD. This rate is held constant for all counties, and was determined by
- 8 previous USGS studies.

9 **Table 4. Residential Medium Growth (2.9 percent) Demand Total**

	Residential Public + Self-supplied(mgd)					
County	2020	2030	2040	2050	2060	2070
Dawson	2.88	3.84	5.11	6.80	9.04	12.04
Forsyth	17.06	22.70	30.22	40.22	53.52	71.24
Gwinnett	90.64	120.64	160.56	213.69	284.41	378.53
Habersham	7.10	9.44	12.57	16.73	22.26	29.63
Hall	18.54	24.68	32.84	43.71	58.18	77.43
Lumpkin	4.93	6.56	8.73	11.62	15.46	20.58
White	3.75	4.99	6.65	8.85	11.78	15.67

10 **Table 5. Residential Public Supply Medium Growth (2.9 percent) Demand Total**

	Residential Public Supply(mgd)					
County	2020	2030	2040	2050	2060	2070
Dawson	2.29	3.05	4.06	5.40	7.17	9.56
Forsyth	16.84	22.40	29.83	39.70	52.82	70.31
Gwinnett	80.18	106.72	142.03	189.02	251.58	334.84
Habersham	5.57	7.40	9.85	13.11	17.45	23.22
Hall	15.76	20.98	27.91	37.15	49.45	65.81
Lumpkin	2.97	3.95	5.26	7.00	9.31	12.39
White	2.44	3.24	4.33	5.76	7.66	10.19

11 **3.3.2 Non-Residential Water Use**

12 For the non-residential sector (hospitals, schools, industrial business, retail, etc.) the
 13 factors that influence demands vary widely; therefore, it was determined that a per unit
 14 use approach would best capture water use in the non-residential sector. For non-
 15 residential water users, the rate of water use per employee is unique to the type of
 16 establishment and the type of work being performed. e.g., water use per employee

1 would be significantly higher at a restaurant where water is being used to wash dishes
 2 and prepare food than at a retail store where water use is for sanitary purposes. The
 3 non- residential water coefficients contain average gallons of water use per employee
 4 per day (GED) for each NAICS category. The water use coefficients represent all water
 5 used at a given establishment on an average day divided by the number of employees.

6 After literature review of NAICS water use coefficients from previous studies it was
 7 determined, the coefficients recently developed for Southwest Missouri Water Resource
 8 Study are a realistic representation of water usage in the seven-county study area. The
 9 coefficients were developed using IWR-Main⁷ methodology and are considered the best
 10 predictors of water usage available without developing study specific coefficients for the
 11 seven-county area. The following industrial NACIS codes and GPD/Employee were
 12 captured in this study and displayed in Table 6.

13 **Table 6. Gallons per Day Values by Industry**

NAICS Sectors		GPD/Employee
11	Agriculture, forestry, fishing and hunting, and mining	112
23	Construction	67
31	Manufacturing	145
42	Wholesale Trade	44
44	Retail Trade	46
48	Transportation and Warehousing, and Utilities	57
51	Information	28
52	Finance and Insurance, and 53-Real Estate and Rental and Leasing	60
54	Professional, Scientific, and Management, and Administrative and Waste Management Services	69
61	Educational Services, and Health Care and Social Assistance	104
71	Arts, Entertainment, and Recreation, and Accommodation and Food Services	33
81	Other Services, Except Public Administration	74
921190	Public Administration	74

14 Non-residential water use is displayed in Table 7 for the medium growth scenario which
 15 is the baseline scenario.

⁷ IWR-Main Water Demand Management Suite: The IWR-Main Water Demand Management Suite is a computerized water resource planning tool that allows the development of water use forecasts and the evaluation of water conservation programs using a combination of econometric demand models and single coefficient requirements models.

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**Table 7. Non-Residential Water Use (mgd)
Medium (2.9 percent) Growth Rate**

County	2020	2030	2040	2050	2060	2070
Dawson	0.97	1.3	1.71	2.28	3.03	4.04
Forsyth	8.02	10.7	14.21	18.91	25.17	33.49
Gwinnett	37.56	50.0	66.54	88.55	117.86	156.86
Habersham	1.92	2.6	3.40	4.52	6.02	8.01
Hall	8.98	12.0	15.91	21.17	28.18	37.51
Lumpkin	1.37	1.8	2.42	3.22	4.29	5.70
White	1.18	1.6	2.09	2.78	3.69	4.92

3.3.3 Agricultural Demand

Agricultural demand is broken out between water supplied for livestock and water supplied for crop irrigation. The annual gallons forecasted for the Livestock sector was developed by taking the number of animals per county, as reported by the 2012 Agriculture Census, and multiplying by the required water needed per animal. Annual usage is then calculated by multiplying daily water required by 365 days. The exception to this is the poultry industry, where a 285-day season is used to account for time between flocks. Analysis of agriculture data is for the historical period from 1997-2012. The largest sector within the agriculture industry is the poultry industry; this sector consumes approximately 70 percent of all water in the counties where the industry is present. The water usage for this industry is determined by a number of factors including: temperature, grow-out methods, management etc. There is substantial variance in the poultry population from year to year, and after analysis of the 1997-2012 data it was determined that a 25 percent + and – variance in baseline agriculture water usage would be included in this study for reference. The agriculture sector water usage was based on the numbers of animals reported in the 2012 agriculture census. This data is considered the most relevant to date. Estimated water use for livestock will be held constant throughout the study period.

Table 8. Livestock Water Use

		Variance From Baseline	
County	Total mgd	-25 percent	+25 percent
Dawson	0.391731	0.293798	0.489664
Forsyth	0.198834	0.149125	0.248542
Gwinnett	0.019971	0.014978	0.024963
Habersham	0.868041	0.651031	1.085051
Hall	0.855528	0.641646	1.069410
Lumpkin	0.259602	0.194702	0.324503
White	0.493533	0.370150	0.616917

1 The baseline developed for the crop irrigation is based on USGS 2010 reported water
 2 data and irrigated acres. All counties in the study area reported irrigated acreage with
 3 Habersham County reporting the highest acreage with 290 irrigated acres, and White
 4 County reporting the lowest acreage with 40 acres. Gallons per acre for crop irrigation
 5 were established by dividing the 2010 USGS reported agricultural water usage per
 6 county by total reported acreage. The gallon per acre was then multiplied by
 7 anticipated growing/irrigation season of 122 days. After review of previous data
 8 obtained from the Agriculture Statistical Service and data provide by USGS for the year
 9 2010 it was determined to hold the acreage constant for the 50-year study period.

10

Table 9. Water Use for Crop Irrigation

County	Crop Acres Irrigated in 2010	Total MG	Gallons/Acre	Gallons/Day	mgd
Dawson	180	0.09	500	738	0.000738
Forsyth	180	0.30	1667	2459	0.002459
Gwinnett	0	0	0	0	0.000000
Habersham	290	0.11	379	902	0.000902
Hall	110	0.28	2545	2295	0.002295
Lumpkin	110	0.12	1091	984	0.000984
White	40	0.05	1250	410	0.000410

11

3.3.4 Irrigation-Golf Sector

12 Analysis for the golf sector of the report is based on 2010 USGS preliminary data. The
 13 analysis provides estimates in an average rainfall year and in a dry year. These
 14 numbers are representative of the Georgia golf course turf water use. The USACE
 15 analysis of the 2010 data set provided by USGS was procedurally the same as the 2005
 16 Georgia EPD Golf Study. The results of both studies were examined and all current
 17 water use, (with the exception of Habersham County which fell below the average
 18 calculated amount) falls between the average and dry year scenario. After review of the
 19 data sets provided by USGS and the EPD Golf course study it was decided that the
 20 median water use of 1,699 gallons per day per acre would be applied to all counties and
 21 annual water usage for each county would be dependent on the number of irrigated
 22 acres in the county. The acreage reported by the 2005 and 2010 data sets revealed
 23 only a slight change in acreage; therefore, each county acreage will be held constant
 24 with the 2010 reported numbers. The annual water usage coefficient used in this
 25 analysis for forecasting is based on median water use per acre in all counties. Annual
 26 usage is median daily use multiplied by the estimated 214-day irrigation season.
 27 Procedures and Assumptions are based on the following study: Water Use for Georgia
 28 Agricultural (Farm Use) Withdrawal Permitted –Golf Courses; Cliff Lewis, Georgia EPD,
 29 Tifton, Georgia.

1 For each county, the “average rainfall year” water use was calculated by multiplying the
 2 total number of permitted acres by 14.06 acre-inches. This calculation provided the
 3 total acre-inch water use in a year of average rainfall, for an April 1 – October 31
 4 growing season. For each county, the “Dry year (no rainfall)” water use was calculated
 5 by multiplying the total number of permitted acres by 30 acre-inches. This calculation
 6 provided the total acre-inch water use in a dry year of no rainfall, for an April 1 –
 7 October 31 growing season. Water use for golf courses is detailed in Table 10.

8 **Table 10. Water Use for Golf Courses**

County	Total Usage	USGS Reported Acreage (2010)	Water Use (Average rainfall year) GPD	Water Use (Dry-No rainfall year) GPD	Average -year mgd	Dry-year mgd	mgd
Dawson	0.21	120	125518.435	267820.274	0.13	0.27	0.20
Forsyth	0.28	170	177817.783	379412.055	0.18	0.38	0.29
Gwinnett	1.85	1000	1045986.959	2231835.616	1.05	2.23	1.70
Habersham	0.16	180	188277.653	401730.411	0.19	0.40	0.31
Hall	1.26	690	721731.0016	1539966.575	0.72	1.54	1.17
Lumpkin	0.16	100	104598.696	223183.562	0.10	0.22	0.17
White	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9 **3.3.5 Total Projected Water Demand**

10 After analysis of all available data it was determined the medium growth rate scenario of
 11 2.9 percent for population growth for the Residential and Non-Residential sectors; with
 12 the remaining sectors per unit usage held constant throughout the study period would
 13 best represent the water demand for the study area. Table 11 illustrates total demand
 14 forecasted by county for all water use sectors.

15 **Table 11. Total Demand Forecast for Medium Growth Scenario**

Total Water Demand Estimate at 2.9 percent Growth Rate						
County	2020	2030	2040	2050	2060	2070
Dawson	4.45	5.72	7.42	9.67	12.67	16.67
Forsyth	32.10	40.40	51.44	66.14	85.71	111.75
Gwinnett	129.92	172.35	228.82	303.97	403.99	537.11
Habersham	14.80	17.78	21.75	27.03	34.06	43.42
Hall	30.54	39.65	51.77	67.91	89.38	117.96
Lumpkin	6.72	8.81	11.58	15.27	20.18	26.71
White	5.42	7.06	9.23	12.12	15.96	21.08
Total	223.96	291.76	382.00	502.11	661.96	874.71

3.3.6 Projected Water Demand for M&I

Based on this independent analysis of water supply demand, the projected M&I water demand for the current and potential future Lake Lanier users are displayed Table 12. Projected M&I water demand for 2040 is approximately 362 mgd which exceeds Georgia's 2013 request. Although USACE did not have the benefit of the assumptions used by the State of Georgia in developing their water demand forecast, this analysis confirms and validates the need for water supply as requested by the State of Georgia. Demonstrating need is a requirement for consideration of reallocating storage

Table 12. Municipal and Industrial Total Water Use Medium Growth (2.9%)

Counties	2020	2030	2040	2050	2060	2070
Dawson	3.85	5.12	6.82	9.08	12.08	16.08
Forsyth	25.08	33.38	44.42	59.12	78.69	104.73
Gwinnett	128.20	170.63	227.10	302.25	402.27	535.39
Habersham	9.01	12.00	15.97	21.25	28.28	37.64
Hall	27.52	36.63	48.75	64.89	86.36	114.94
Lumpkin	6.29	8.38	11.15	14.84	19.75	26.28
White	4.93	6.56	8.73	11.62	15.47	20.59
Total	204.89	272.70	362.94	483.04	642.89	855.64

4.0 Water Supply Alternatives

4.1 Preliminary Alternatives

An array of potential sources for water supply for those water supply providers currently withdrawing from Lake Lanier is summarized as follows:

- Conservation
- Groundwater
- Desalination
- Existing surface water sources (other than Lake Lanier)
- Reallocation from Flood Control Storage
- Reallocation from Inactive Storage
- Reallocation from Conservation Storage
- New Reservoir Construction
- Chattahoochee River Withdrawal and Pumping

1 **4.2 Future Without Project Condition**

2 The Future Without Project Condition (FWOPC) is the condition expected to exist in the
3 future in the absence of reallocation of storage under the 1958 Water Supply Act for
4 those communities currently withdrawing water from Lake Lanier under expired
5 agreements. If storage were not reallocated from Lake Lanier for water supply, it is
6 reasonable to assume that Glades Reservoir would be constructed and contribute 40
7 mgd to the water supply need. The assumption that Glades Reservoir would be
8 constructed is made for analytical purposes only and does not constitute an agency
9 decision on the merits of the project⁸. The FWOPC provides the basis from which
10 alternative plans are formulated for the WSSA. In the FWOPC releases would be made
11 from Buford Dam to support the 2007 downstream withdrawals of 408 mgd. The
12 FWOPC is the same as Alternative 7C (Alt7C) in the EIS.

13 The Hall County Board of Commissioners, Hall County, Georgia, has proposed to
14 construct a water supply reservoir project in Hall County to operate as part of the public
15 water supply system. The proposed Glades Reservoir would be a pumped-storage
16 facility located on Flat Creek about 0.8 mi upstream of its confluence with the
17 Chattahoochee River at the headwaters of Lake Sidney Lanier. Although the safe yield
18 as stated in the permit application is approximately 72.5 mgd, Georgia’s 2013 request
19 indicated that Glades Reservoir would provide 40 mgd for Hall County’s 2040 need.
20 Withdrawals from this reservoir would be return water into Lake Lanier.

21 **4.3 Alternatives Considered but Eliminated from Further**
22 **Consideration**

23 **4.3.1 Conservation**

24 Conservation is often the first step in reducing consumption and overall demand for
25 water supply. Water providers within the district have been implementing multiple
26 conservation measures to reduce demand. Conservation has been an important focus
27 of the MNGWPD and is included as a cornerstone of their water supply plan. Measures
28 include conservation pricing, leak detection and repair, plumbing and toilet retrofit
29 programs, education programs, multi-family sub-metering, and water recycling (e.g. car
30 washes). In 2011 per capita water use for the metro area was 148 gpcd (gallons per
31 capita per day). Georgia Environmental Protection Division GAEPD projects water use
32 will decrease to an average of 135 gallons per capita day (gpcd) by 2040. It is unlikely
33 that additional conservation measures would result in a significant reduction in
34 Georgia’s 2040 need. To the extent that the MNGWPD adopts additional conservation
35 measures, Georgia’s 2013 request will satisfy needs beyond 2040.

⁸ As of August 2015, USACE Savannah District Regulatory Division is considering a permit application for construction of Glades Reservoir.

1 **4.3.2 Groundwater**

2 Following the Phase I ruling of the Federal District Court for the Middle District Court of
3 Florida in July 2009, the State of Georgia created the Water Task Force to develop a
4 contingency plan to prioritize a set of water conservation and water supply options. The
5 report detailed options for meeting the water supply needs of current and future Lake
6 Lanier users if water withdrawals from Lake Lanier and releases from Buford Dam were
7 halted. The report was prepared by a collection of A-E firms and stakeholders. In the
8 Georgia Water Task Force Report that was completed in 2009, ground water was
9 evaluated as a potential option to meet the water supply needs of the stakeholders.
10 The potential ground water sources identified were either for non-potable reuse or were
11 located in isolated areas and in relatively small quantities and would not be readily
12 available to water supply systems dependent on Lake Lanier. Groundwater resources
13 in MNGWPD are limited in quantity and are quite costly compare to other options,
14 therefore, are not considered adequate potential sources of water supply and were
15 eliminated from further evaluation.

16 **4.3.3 Desalinization**

17 The Georgia Water Task Force Report evaluated desalinization as a potential option to
18 meet the water supply needs of the stakeholders. The study showed an estimated cost
19 of approximately \$21 billion over the project life. While the preliminary evaluation
20 showed that this option could supply approximately 200 million gallons per day, this was
21 seen as the most expensive option and, therefore, is not carried forward in our
22 evaluation.

23 **4.3.4 Existing Surface Water Sources (other than Lake Lanier)**

24 The Georgia Water Task Force Report also evaluated the feasibility of existing surface
25 water sources to meet the need if Lake Lanier and Buford Dam could no longer be
26 operated for water supply. Potential sources include Lake Burton, West Point Lake,
27 Lake Hartwell, and Nickajack Reservoir. Several of these sources would require inter-
28 basin transfer agreements or legislation. Further, based on information in the report,
29 none of these sources would satisfy the 2040 water supply need. All of these transfers
30 were considered contentious or highly contentious by the stakeholders involved.
31 Additionally, obtaining water from another USACE reservoir would require reallocation
32 of storage. Existing surface water sources were not carried forward for further
33 evaluation.

34 **4.3.5 Reallocation from Flood Control Storage and Inactive Storage**

35 Flood storage at Buford Reservoir exists between elevations 1071 and 1085 and
36 consists of 598,800 ac-ft. Reallocation from the flood pool could accommodate a
37 portion of the future demand; however, this alternative will not be carried forward for

1 further evaluation for several reasons. Reallocation from the Lanier flood pool would
2 represent an increased flood risk because compromised downstream channel capacity
3 and development encroachment restrict flood water releases from Buford Dam to
4 10,000 cfs. Because flood releases must be limited to 10,000 cfs, it is necessary to
5 maintain maximum amount of flood storage. Additionally, a permanent incursion into
6 the flood pool could represent a dam safety risk due to saddle dike leaks that would
7 increase as flood waters are retained; increased guide curve elevations would impact
8 recreation facilities and private property resulting in significant economic impacts as well
9 as increased shoreline erosion.

10 Reallocation from inactive storage was considered and eliminated from further
11 consideration because the Buford hydropower project is designed with head limits at the
12 bottom of the conservation pool. The design of hydropower equipment at Buford Dam
13 is optimized to function within the head range which corresponds to the conservation
14 pool. Operation below the minimum rated head (bottom of conservation pool, inactive
15 pool) would result in excessive cavitation and often vibration which could damage
16 equipment. In addition operation in this range would decrease the efficiency and output
17 of the unit.

18 **4.4 Action Alternatives**

19 The following alternatives are considered to satisfy some or all of the water supply need
20 for users upstream of Buford Reservoir. The projected need of 408 mgd for
21 downstream users would be met regardless of which of these alternatives might be
22 implemented.

23 **4.4.1 Reallocation from Conservation Storage**

24 Varying levels of reallocation from conservation storage at Lake Lanier were evaluated
25 in the EIS including the following:

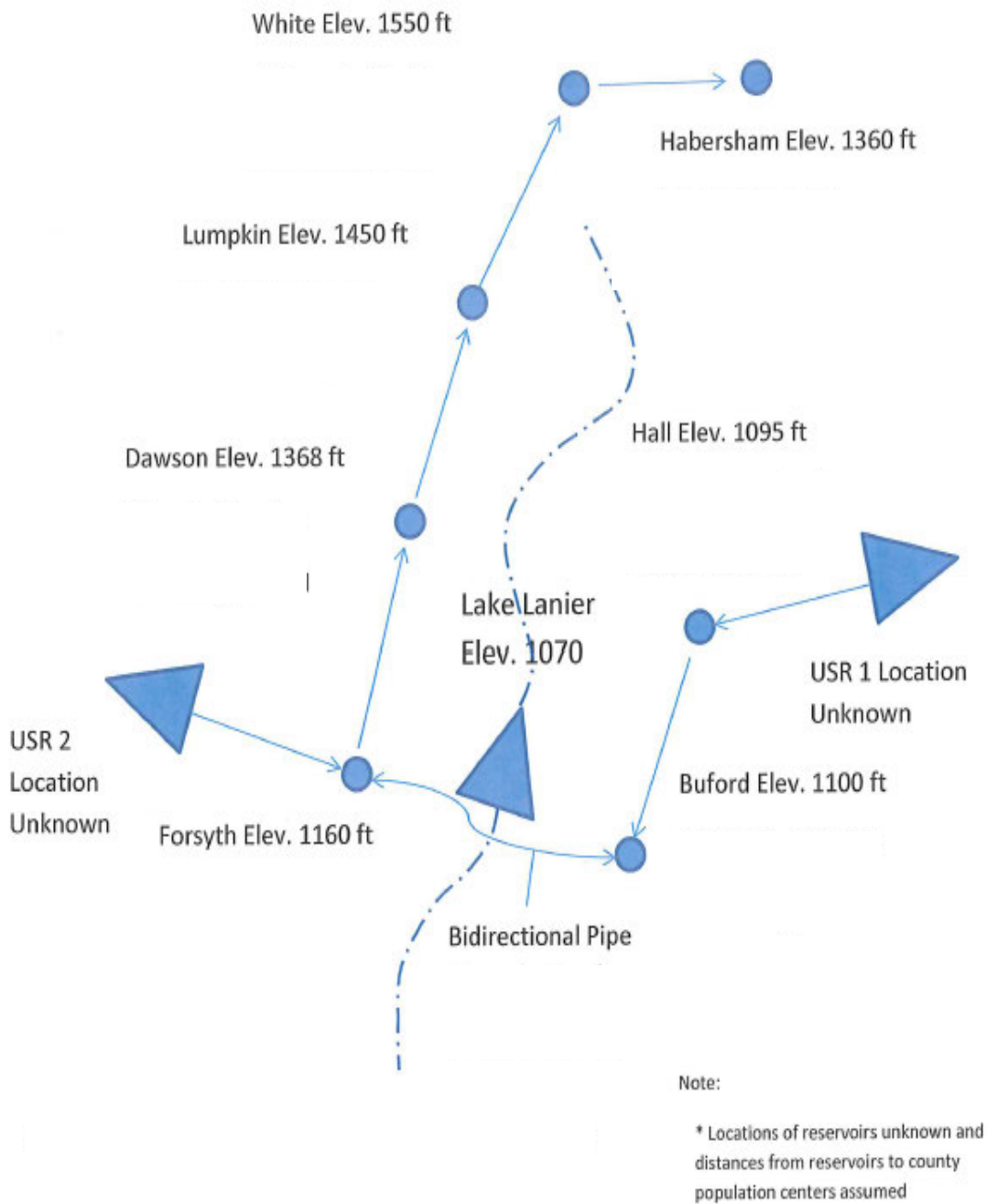
- 26 • Current (2007) withdrawals (128 mgd), including 20 mgd for relocation contracts.
27 (108 mgd would be considered for reallocation under the authority of the 1958
28 WSA).
- 29 • 297 mgd (Georgia's 2013 request, including 20 mgd relocation contracts and 277
30 mgd under the authority of the 1958 WSA).
- 31 • 257 mgd (including 20 mgd relocation contracts and 237 mgd under the authority
32 of the 1958 WSA) with 40 mgd provided by Glades Reservoir.
- 33 • 225 mgd (including 20 mgd relocation contracts and 165 mgd under the authority
34 of the 1958 WSA) with 40 mgd being provided by Glades Reservoir.

35 A preliminary evaluation of the effects of providing various levels of water supply from
36 Lake Lanier indicated that Georgia's 2013 request for withdrawing 297 mgd and

1 returning 55 percent, for a net withdrawal of 134 mgd, indicated that the impacts stated
2 would continue to allow USACE to operate in a balanced manner. However, the return
3 rate assumed in Georgia's request was overly optimistic when compared to the waste
4 treatment infrastructure expected to be in-place by 2040. Based on the USACE
5 analysis of potential wastewater returns to Lake Lanier discussed in Section 5.1.4.1 of
6 the EIS, a return of treated wastewater amounting to 91 mgd was readily achievable
7 given the infrastructure and best management practices expected to be in-place by
8 2035. Adding 134 mgd, an achievable net withdrawal, and 91 mgd, the expected return
9 in 2040, results in 225 mgd gross withdrawal that can be supported by some
10 combination of Lake Lanier and Glades Reservoir.

11 **4.4.2 New Reservoir Construction**

12 Under this alternative a several new water supply reservoirs would need to be
13 developed upstream of Lake Lanier or on a tributary to Lake Lanier. At this time specific
14 sites have not been identified. The location, size, pump capacity, hydrologic
15 information, and safe yield for any individual reservoir cannot be determined without a
16 much more detailed study that would accompany actual pursuit of such an option. Costs
17 for this alternative were based on recently constructed or proposed reservoirs and are
18 discussed in Section 6 of this assessment (refer to Table 19). Figure 3 displays a
19 conceptual map of the location of these new reservoirs. It is not known if incremental
20 water treatment and wastewater treatment costs would be incurred by implementing this
21 option.



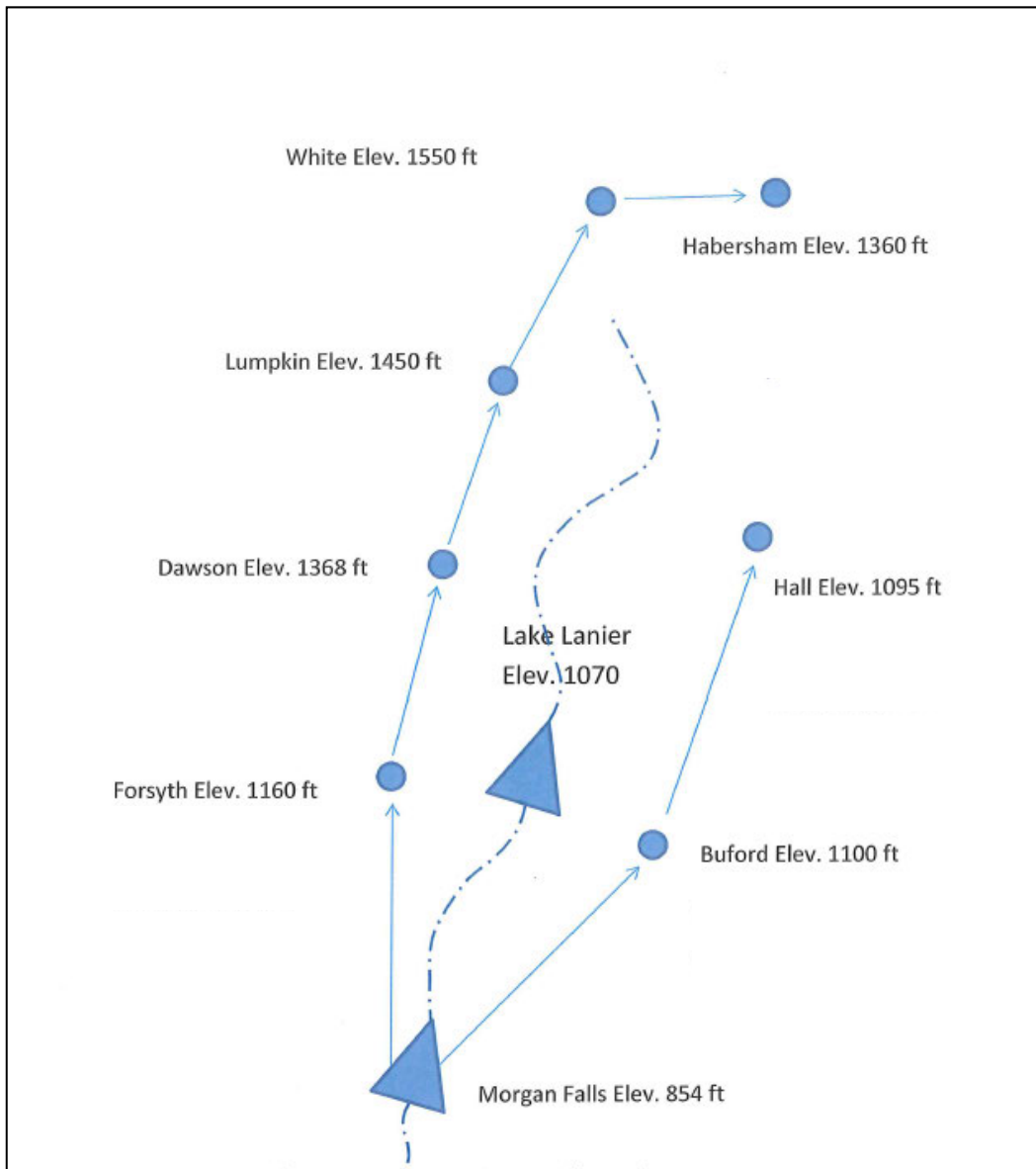
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2 **Figure 3. New Reservoir Conceptual Locations**
3 **Source: Georgia EPD, 2014**
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1 **4.4.3 Chattahoochee River Withdrawal and Pumping System**
2 **Alternative**

3 Another alternative considered would involve constructing new intakes for withdrawing
4 water from the Chattahoochee River downstream of Buford Dam and pumping it
5 upstream for use by users that otherwise would withdraw directly from Lake Lanier.

6 It is assumed that a pipeline would be constructed on the eastern side of the
7 Chattahoochee River to carry water to meet the water supply needs of Gwinnett County,
8 City of Buford, Hall County, and City of Gainesville, and that a pipeline would be
9 constructed on the western side of the Chattahoochee River to meet the needs of
10 Forsyth County, City of Cumming, Dawson County, Lumpkin County, White County, and
11 Habersham County. It is not known if incremental water treatment and wastewater
12 treatment costs would be incurred by implementing this option.

13 The cost of this option would result from piping systems and associated pump stations.
14 (Refer to Table 19) It is assumed the location of the pump station to be Georgia Power
15 Company's Morgan Falls Dam. A potential piping configuration is shown in Figure 4.



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Figure 4. Conceptual Map of Chattahoochee River Withdrawal and Pumping Alternative
Source: Georgia EPD, 2014

4.5 Alternative Evaluation

In order to evaluate the impacts for the varying levels of reallocation considered, the varying levels of water supply were modeled as part of the ResSim Analysis. The USACE Hydrologic Engineering Center (HEC) developed ResSim, the software that is now the standard for USACE reservoir operations modeling. The software incorporates characteristics of the basin and individual reservoirs including physical constraints

1 (spillway capacities, area-discharge curves, flows associated with hydroelectric power
2 generation, and such) and operational procedures (action zones, balancing, and the
3 like). For further description refer to Section 4.1 of the EIS. ResSim provides outputs in
4 terms of reservoir levels, river flows, hydropower generated over the historical period. A
5 full discussion of the complete water supply and water management alternatives is
6 presented in Section 5 of the EIS. Environmental impacts analyses are discussed in
7 Section 6 of the EIS.

8 **4.6 Proposed Action Alternative**

9 Based on the results from the impacts analysis in the EIS, as well as the reasons stated
10 in the discussion above, the Proposed Action Alternative has a gross withdrawal
11 amount of 225 mgd which includes, a reallocation of 165 mgd or 189,497 acre feet,
12 20 mgd for relocation agreements) and 40 mgd from Glades Reservoir has been
13 selected as the proposed action alternative. This storage reallocation will also
14 accommodate the current need of 128 mgd from Lake Lanier. This alternative will
15 provide for 408 mgd downstream of Atlanta. The rationale for selecting the Proposed
16 Action Alternative is discussed in more detail in Section 5.3 of the EIS.

17 **5.0 Derivation of User Cost**

18 **5.1 Methodology**

19 USACE's Engineer Regulation (ER) 1105-2-100 specifies the four pricing methods used
20 to calculate the value of storage considered for reallocation (i.e., the price to be charged
21 for the capital investment for the reallocated storage). The four methods include:
22 benefits foregone, revenues foregone, replacement cost, and updated cost of storage.
23 The value placed on the storage is the highest of the four methods.

- 24 • **Benefits Foregone.** Benefits foregone are generally estimated using the
25 standard National Economic Development (NED) evaluation criteria in
26 compliance with ER-1105-2-100. The benefits foregone are evaluated over a 50-
27 year period of analysis.
- 28 • **Revenues Foregone.** Hydropower revenues foregone are defined as the
29 reduction in revenues accruing to the Treasury as a result of reallocating storage
30 from hydropower to water supply. The revenues are based on the existing
31 repayment agreement between the power marketing agency and the USACE.
32 Revenues forgone from other project purposes are the reduction in revenues
33 accruing to the U.S. Treasury based on existing repayment agreements.
- 34 • **Replacement Cost.** Notwithstanding unforeseen circumstances, replacement
35 costs are equal to benefits foregone. In the event that reallocated storage is

1 being taken from the flood control pool, the USACE will estimate the replacement
2 cost of equivalent protection.

- 3 • Updated Cost of Storage. The updated cost of reallocated storage is estimated
4 by updating the cost of the joint use features from the midpoint of construction to
5 the fiscal year in which the reallocation of storage is approved. The updated cost
6 of the joint use features is then multiplied by the proportion of useable storage
7 that is to be reallocated to estimate the value of the reallocated storage.

8 If the cost of reallocated storage is less than the cost of the most likely alternative non-
9 Federal source of water supply, the reallocation is considered to be feasible. The
10 reallocation is feasible because, net marginal benefits associated with water supply are
11 greater than benefits associated with the displaced project purpose (USACE, 2000).

12 **5.2 The Value of Storage**

13 **5.2.1 Benefits Forgone**

14 Benefits forgone are calculated for the ACF federal project in accordance with guidance
15 in the ER 1105-2-100. There are no benefits forgone calculated for flood risk
16 management or from navigation. Because there was no change in the level of flood risk
17 management and the reallocation considered is out of the conservation pool, there are
18 no benefits forgone for the flood control project purpose. While there is improved
19 channel availability on the ACF System, no NED benefits were evaluated due to the
20 lack of consistent commodity movements over the last decade. Therefore, there are no
21 benefits forgone to the navigation project purpose.

22 Benefits forgone are calculated for both the hydropower project purpose and for
23 recreation. A full description of the methodology for NED hydropower impacts is
24 contained in Appendix D to this WSSA and the recreation benefit analysis is contained
25 in Appendix M of the EIS. Benefits forgone are summarized in Table 13 in average
26 annual dollars based on the 2015 price levels, a 3.375 percent interest rate and a period
27 of analysis of 50 years. It should be noted that impacts to project purposes discussed in
28 Section 6 of the EIS are a comparison of the No Action Alternative to the Proposed
29 Action Alternative. The WSSA displays the comparison between the Without Project
30 Condition (Alt7-C) and the Proposed Action Alternative.

31

Table 13. Benefits Forgone

Alternative	Total Benefits (Federal System)	Benefits Foregone compared to baseline (Without Project Future Condition)
With Out Project Condition Alt 7C	\$221,161,000	\$0
Hydropower	\$90,473,000	\$0
Recreation	\$130,688,000	\$0
Reallocation of 189,497 acre-feet (165 mgd)	\$219,497,000	-\$1,664,000
Hydropower	\$89,106,000	-\$1,367,000
Recreation	\$130,391,000	-\$297,000

Note: Average Annual Dollars at 2015 price level

5.2.2 Revenues Forgone

Revenues forgone are calculated for the ACF federal system in accordance with guidance in the ER 1105-2-100. There are no revenues foregone for flood risk management, navigation, or recreation project purposes. A detailed discussion of the hydropower revenues forgone calculations and methodology is found in Appendix D of the WSSA. Revenues forgone are based on the 2015 price levels, a 3.375 percent interest rate and a period of analysis of 50 years. Revenues forgone are \$484,779 for the 165 mgd reallocation alternative (Alt 7H in the EIS).

Table 14. Hydropower Revenues Forgone

Alternatives	Estimated Revenue	Revenue Foregone
With Out Project Condition Alt 7C	\$42,413,543	\$0
Reallocation of 189,497 ac-ft (165 mgd)	\$41,928,764	(484,779)

Note: Revenues and revenues foregone are displayed in average annual dollars.

5.2.3 Replacement Cost

No replacement cost was calculated for flood risk management as the volume of storage considered for reallocation would come from the conservation pool. The replacement cost of power is equivalent to the hydropower benefits forgone. Replacement Cost of Power, therefore, is \$1,367,000 for the 165 mgd reallocation alternative.

5.2.4 Updated Cost of Storage

The cost allocated to the user under this pricing method updates the joint-use portion of the first costs of reservoir construction to present day price levels and then assigns a percentage of the costs based on the "Use of Facilities" (UOF) cost allocation procedure. Costs are updated from "as built" costs in 1953 (the mid-point of construction) to 1967 prices by use of the Engineering News Record (ENR) Construction Cost Index, and then from 1967 to current prices by use of the USACE's Civil Works Construction Cost Index System (CWCCIS). Land values are updated by the weighted average update of all other project features. Costs are indexed from the

1 midpoint of the physical construction period to the beginning of the FY in which the
 2 contract for the reallocated storage is expected to be approved (FY2017). Joint-use
 3 costs shown in Table 16 exclude infrastructure costs allocated to specific project
 4 purposes such as recreation facilities, hydropower turbines, etc.

5 Construction is considered as having been initiated at the start of the month when lands
 6 for the project were first acquired or on the date when the first construction contract was
 7 awarded whichever was earlier. Construction is considered as having been completed
 8 at the end of the government FY in which final deliberate impoundment of the reservoir
 9 pool was initiated.

10 The USACE policy on pricing storage reallocated from one authorized project purpose
 11 to another is based on the “UOF” methodology. Use of Facilities methodology allocates
 12 joint-use costs (costs that cannot be specifically allocated to a specific project purpose)
 13 based on overall percentage of storage reallocated. For example, if 11 percent of the
 14 usable storage is reallocated, then the reallocated storage is apportioned 11 percent of
 15 the joint-use costs. The cost of reallocated storage changes each government FY. This
 16 is due to the fact that the Federal discount rate changes on an annual basis as well as
 17 varying annual operation, maintenance, repair, replacement, and rehabilitation costs
 18 (OMRR&R). Section 932 of the 1986 WRDA requires recalculation of the interest rate
 19 at 5-year intervals if the storage is paid annually over a 30-year period.

20 **5.2.5 Cost of Reallocated Storage**

21 The updated cost of storage is the highest of the four comparable costs; therefore, the
 22 updated costs of storage will be used to determine the user cost. Table 15 displays the
 23 results of the four pricing methods for comparison.

24 **Table 15. Costs of Reallocated Storage**

	Benefits Foregone compared to baseline (Without Project Future Condition)	Revenue Foregone	Replacement Cost	Updated Cost of Storage
With Out Project Condition Alt 7C	\$0	\$0	\$0	\$0
Reallocation of 189,497 acre-feet (165 mgd)	-\$1,664,000	-\$484,779	-\$ 1,367,000	\$2,053,000

25 Note: Costs are displayed in 2015 average annual dollars

26 The percent of usable storage is calculated in Table 16. The storage cost calculations
 27 for the 189,497 ac-ft is shown in Tables 17. The cost calculations are based on the
 28 updated cost of storage of \$404,293,000 and a 5-year average OMRR&R costs of
 29 \$1,424,453. The updated cost of storage over a 50-year period is \$2,053,000.

1

Table 16. Update Joint-Use Costs

Category	Actual Joint use as of Mid-point of construction 1953	1953 ENR Index Ratio	1967 ENR Index	ENR ratio	1967 CWCCIS Index Base 100	Updated Joint-Use as of 1967	Sep 2017 CWCCIS Index	Update Factor	FY 2017 Joint Costs
Lands and Damages	10,184,000	600	1070	1.78	100	18,161,000	848.29	8.48 ¹	154,058,000
Relocations	10,200,000	600	1070	1.78	100	18,190,000	821.67	8.22	149,462,000
Reservoir	2,191,000	600	1070	1.78	100	3,907,000	889.48	8.89	34,752,000
Dam	3,857,000	600	1070	1.78	100	6,878,000	781	7.81	53,713,000
Access Roads	436,000	600	1070	1.78	100	778,000	821.65	8.22	6,392,000
Buildings, Grounds, and utilities	276,000	600	1070	1.78	100	492,000	817.07	8.17	4,020,000
Permanent operating equipment	130,000	600	1070	1.78	100	232,000	817.07	8.17	1,896,000
Total	27,273,000		1070						404,293,000
Specific Costs Water Supply Conduit	Intakes already present								

2 1. Update factor for Lands and Damages acct was based on a weighted average of update factors for all other accounts.

3 Source: USACE (U.S. Army Corps of Engineers). 1960. Cost Allocation Studies: Apalachicola, Chattahoochee, and Flint River Project. U.S. Army Corps of Engineers, Mobile, AL.

1

Table 17. Lake Storage

Feature	Elevation (feet, NGCD)		Usable Storage (acre-feet)	Percent of	
				Usable Storage	Conservation Storage
Flood Control	1071	1085	598,800	35.51	
Conservation	1035	1071	1,087,600	64.49	100.00
Water Supply			189,497	11.24	17.42
State of Georgia			189,497	11.24	17.42
Other Conservation Purposes [list as appropriate]					
Total Usable Storage			1,686,400	100.00	

2

Table 18. Cost of Storage

Total Usable Storage for Lake Lanier (STot)	1,686,400 ac-ft
Storage Recommendation (SRec)	189,497 ac-ft
Percent of Total Conservation Storage P = SReq/ STot = 189,497 / 1,087,000	11.24%
Total Updated Cost of Storage for Lake Lanier (CTot)	\$404,293,000
Cost of Storage Recommendation (CRec) CRec= P x CTot	\$ 45,430,000
Annual Cost of Storage Recommendation (ARec)	Over 50 years*
$A_{Rec} = \frac{i(1+i)^n - 1}{(1+i)^n - 1} C_{Rec}$	Where: CRec = \$ i = 3.375% discount rate ,N = 50 year \$1,893,000
Operation and Maintenance for Lake Lanier(O&MTot)	\$ 1,424,453
Lake Lanier Annual Operation and Maintenance Estimate (O&MRec) O&MRec = P x O&MTot	\$ 160,000
Lake Lanier Annual Replacement, Repair and Rehabilitation Estimate (R,R&RRec) R,R,&RRec = P x R,R,&RTot	
Total Annual Cost =ARec + O&MRec + R,R&RRec (Average Annual \$)	\$2,053,000

3

Notes:

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1 Five-year (FY2010-FY2014) Average of Operations and Maintenance cost in \$2015 price level.

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2. There has been no R,R,&R costs in the last 5 years.

6

5.3 Credit to the Power Marketing Agency

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Per ER 1105-2-100, when hydropower is adversely impacted by reallocation of the

8

conservation pool to satisfy additional water supply needs, hydropower losses can be

9

mitigated through the provision of financial credit. In this case, credits would be

1 provided to the hydropower account from a portion of the water supply storage
2 proceeds. This credit is based on revenues foregone to the United States Treasury for
3 repayment of the hydropower costs allocated to the project. Revenues foregone reflect
4 the allocated costs to power upon which the rates are based. When reallocation is
5 accomplished through this credit approach, in essence, the allocation of costs is
6 adjusted without performing a laborious new cost allocation. Additionally, where
7 existing Federal power delivery contracts require market purchases of power as a result
8 of storage reallocations and withdrawals, the power marketing agency may obtain an
9 additional credit for the funds expended for those purchases upon demonstration that
10 they were made as a direct result of the reallocation.

11 Hydropower credits will not be given for losses that occur at non-federal facilities.
12 Withdrawals from Lake Lanier covered under the original relocation contracts and
13 releases for downstream withdrawals under the 1946 RHA will not result in credits to
14 SEPA, because both of these actions were originally authorized and are not a
15 reallocation. Credits are calculated based on hydropower losses that resulted from
16 reallocation of 189,497 ac-ft of storage. These credits will not be given directly to SEPA,
17 but will apply for Department of Energy payback to the U.S. Treasury.

18 Power Marketing Agency credits are displayed in Table 38 in Appendix D in the
19 Hydropower Analysis Report.

20 **6.0 Test of Financial Feasibility**

21 To test the financial feasibility of the reallocation, the annual cost of the reallocated
22 storage is compared to the annual cost of the most likely, least costly, alternative water
23 supply source that would provide an equivalent quality and quantity of water if storage
24 reallocation at Lake Lanier were not an option for the water supply customers. The
25 following sections present the evaluation of two potential alternatives sources for the
26 State of Georgia and the identification of the most likely, least costly water supply
27 source if storage reallocation at Lake Lanier were not an option.

28 **6.1 Least Costly Water Supply Alternatives to Meet Future** 29 **Regional Demands**

30 The forecasts for regional water demands for current and future Lake Lanier users and
31 an inventory of existing and potential sources of water supply have been shown in
32 previous sections of the report. These demands and existing and potential sources of
33 water supply were comprehensively discussed in the 2009 Water Supply and Water
34 Conservation Management Plan and the 2009 Georgia Water Task Force Report. The
35 State of Georgia has identified Lake Lanier water as its main source of water supply to
36 meet forecast needs through 2035 because of existing withdrawal and distribution
37 infrastructure, including pipelines and water treatment facilities. Maximum stated waste

1 water treatment capacity through 2035 is expected to be 156.94 mgd. This is achieved
 2 through expanding existing facilities and constructing new facilities. Current and
 3 proposed water treatment facilities will provide enough capacity for the 2040 needs at
 4 Lake Lanier. The State of Georgia has identified Lake Lanier as the preferred source to
 5 meet a portion of future needs.

6 The State of Georgia will require water from Lake Lanier currently and beyond the
 7 immediate need. The State of Georgia is also planning for additional water supply
 8 sources in the future to accommodate additional needs of its users. Other sources are
 9 not expected to be realized in the near term because of the large financial resources
 10 required (hundreds of millions of dollars) and the need to consider social and
 11 environmental impacts. Two such alternatives being considered that could be
 12 implemented in the absence of reallocation are described below.

- 13 • A Chattahoochee River withdrawal and pumping system alternative would consist
 14 of constructing a pump and pipeline system downstream of Buford Dam and
 15 pumping the water upriver to existing treatment plants for distribution. Georgia
 16 proposed costs for this alternative are \$1.2 billion.
- 17 • New reservoir development including potential construction both east and west of
 18 Lake Lanier. Proposed cost by the State of Georgia was approximately \$1.4
 19 billion.

20 Total and annual costs (including operation and maintenance costs) for both
 21 alternatives are displayed below in Table 19. These costs were provided by the State of
 22 Georgia in a letter to USACE on May 30, 2014 (Appendix B to this assessment) which
 23 stated that these costs were likely very conservative due to the unknown costs of
 24 potential environmental impacts, site specific costs, etc. The level of detail for these
 25 proposed costs was considered acceptable given the nature of their use in this analysis.
 26 A validation of these costs was provided by the USACE cost engineering team. This
 27 validation is included as Appendix C to this assessment.

28 **Table 19. Costs of Two Possible Least Costly Alternatives Least Costly Alternatives**

Alternative Supply Total Cost (2015 Prices)	Average Annual Cost/ Total Cost (June 2015)	Water Supply Yield (mgd)	Cost Per mgd (June 2015)
Chattahoochee River Withdrawal and Pumping System	\$51,150,000 \$1,199,755,000	165	\$7.27 Mil
New Reservoir(s)	\$60,267,000 \$1,413,596,000	165	\$8.57 Mil

6.2 Most Likely Water Supply Alternative to Meet Future Regional Demands

The proposed Chattahoochee River Withdrawal and Pumping System would likely be implemented by multiple entities within the state. The system would serve users on both sides of Lake Lanier. The total capital cost of the proposed withdrawal and pumping system in FY 2015 dollars is estimated to be \$1.2 billion. The total water supply yield of the withdrawal and pumping system is 165 mgd.

The total cost and the quantities of water required for new sources of water supply by year 2035 indicate that the withdrawal and pumping system would be the most likely and least costly choice for a new source of water supply.

The proposed system would be the most likely and least costly water supply alternative to (the existing source) Lake Lanier storage reallocation. The proposed withdrawal and pumping system is estimated to supply about 165 mgd for the State of Georgia (Lake Lanier users) and would have an estimated average annual cost of about \$51,150,000. The Lake Lanier storage reallocation for the State of Georgia, with an average annual cost of \$2,053,000 and an estimated yield of about 165 mgd, passes the test of financial feasibility without further analysis. The benefit-to-cost ratio is approximately 24.9:1. (The economic value of "\$2,053,000" represents the FY 2017 updated cost of storage annualized over a 50-year period at a discount rate of 3.375 percent and does not represent the annual water storage agreement payments amortized over 30 years.)

7.0 Tentative Recommendation

The independent sector level water demand analysis completed by USACE validated that need by the State of Georgia in consideration for their request for storage from Lake Lanier.

A reallocation of water supply storage from conservation storage does not occur until water storage agreements are signed by all parties and the water supply user starts to pay for the storage. Therefore, the actual reallocation is often incremental and is implemented upon execution of water storage agreements. The storage authorized for reallocation, but not under agreement, is considered by the USACE to be conservation storage and is considered to be available to all authorized project purposes. The ASA(CW) has the authority to approve this reallocation of storage and the associated water supply agreements.

An EIS was prepared that presents the environmental effects of updating the Water Control Manual for the ACF together with consideration of an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier Project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013

1 requested from Lake Lanier and downstream at Atlanta. Impacts are discussed by
2 project purpose and by resource area in Section 6 of the EIS.

3 For the reallocation of 189,497 ac-ft of storage, benefits forgone would consist of
4 reduced energy and capacity that the Southeastern Power Authority (SEPA) could
5 market as well as recreation impacts. The average annual impact measured as benefits
6 forgone (both hydropower and recreation), evaluated over a 50-year economic
7 evaluation period and a discount rate of 3.375 percent, would be \$1,367,000.

8 Average annual water supply benefits for the reallocation of 189,497 ac-ft of storage
9 (about 165 mgd), evaluated over a 50-year economic evaluation period and a discount
10 rate of 3.375 percent, would be \$51,150,000 (including O&M). This value is based on
11 the least costly, most likely alternative costs that would be implemented in the absence
12 of reallocation from Lake Lanier.

13 To test the financial feasibility of Lake Lanier storage reallocation, the annual cost of the
14 proposed reallocated storage was compared to the annual cost of the most likely, least
15 costly, water supply source that would provide an equivalent quality and quantity of
16 water if storage reallocation at Lake Lanier was not an option for the State of Georgia.
17 The proposed Chattahoochee River Withdrawal and Pumping scenario was found to be
18 the most likely and least costly water supply alternative to Lake Lanier storage
19 reallocation. The proposed withdrawal and pumping scenario can supply about 165
20 mgd for the State of Georgia and would have an estimated average annual cost of
21 about \$51,150,000. The Lake Lanier storage reallocation, with an average annual cost
22 of \$2,053,000, passes the test of financial feasibility by a factor of more than 24.9:1.

23 Based on the foregoing, it is tentatively recommended to reallocate 189,497 ac-ft of
24 conservation storage to water supply. This alternative is the most cost effective and
25 timely response to satisfy a portion of the projected water demands in the State of
26 Georgia for current and potential Lake Lanier users. The annual first cost to the user is
27 \$2,470,000 as shown in Table 20. An estimate of the user's share of annual O&M cost
28 is \$160,000. The annual payment will also include the user's share of repair,
29 rehabilitation, and replacement (R, R, and R) cost. There have been no R,R,R, costs to
30 date and the estimated annual payment of \$2,630,000 is displayed in the table below.

1
2

**Table 20. Total Annual Cost to User
for the Reallocated Water Supply Storage**

Total Usable Storage for Lake Lanier (STot)		1,686,400 ac-ft
Tentative Storage Recommendation (SRec)		189,497 ac-ft
Percent of Total Conservation Storage P = SRec/ STot		11.24%
Total Updated Cost of Storage for Lake Lanier (CTot)		\$404,293,000
Cost of Tentative Storage Recommendation (CRec) CRec= P x CTot		\$45,430,000
Annual Cost of Tentative Storage Recommendation (ARec)		
$A_{Rec} = C_{Rec} \frac{i(1+i)^n - 1}{(1+i)^n - 1}$	Where: CRec = \$ i= 3.375% discount rate +.125% N = 30 year ³	\$2,470,000
Operation and Maintenance for Lake Lanier(O&MTot)		\$1,424,453
Lake Lanier Annual Operation and Maintenance Estimate (O&MRec) O&MRec = P x O&MTot		\$160,000
Lake Lanier Annual Replacement, Repair and Rehabilitation Estimate (R,R&RRec) R,R,&RRec = P x R,R,&RTot		\$ -
Total Annual Cost =ARec + O&MRec + R,R&Rrec (Average Annual \$)		\$2,630,000

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Notes:

1. Five-year (FY2010-FY2014) Average of Operations and Maintenance cost in \$2015 price level.
2. There has been no R,R,&R costs in the last 5 years
3. Section 932 of the 1986 WRDA requires recalculation of the interest rate at 5-year intervals if the storage is paid annually over a 30-year period.

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1 Bibliography

2

3 Georgia Environmental Protection Division Golf Study, 2005

4 Georgia Office of Planning and Budget, Report. dated March 12, 2010

5 J. Turner for Georgia Environmental Protection Division, personal communication, January 11, 2013

6 Metropolitan North Georgia Water Planning District, Water Supply and Conservation Management Plan.
7 May 2009

8 National Agricultural Statistical Service, 2012 Agricultural Census. www.nass.usda.gov

9 National Agricultural Statistical Service, www.nass.usda.gov. Accessed July 2014

10 USACE, Engineering Regulation 1105-2-100. Planning Guidance Notebook. 2000

11 USACE, Southwest Missouri Water Resource Study. September 2012

12 USACE, Water Supply Handbook, Dec 1998, Revised Institute for Water Resources (IWR) Report 96-
13 PS-4

14 USGS, personal communication. August 2014

15 Water Contingency Planning Task Force Report. December 21, 2009

16 Water Use for Georgia Agricultural (Farm Use) Withdrawal Permitted –Golf Courses; Cliff Lewis,
17 Georgia EPD, Tifton, Georgia.

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Appendix A: Georgia 2013 Water Supply Request

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STATE OF GEORGIA
OFFICE OF THE GOVERNOR
ATLANTA 30334-0900

Nathan Deal
GOVERNOR

January 11, 2013

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army for Civil Works
108 Army Pentagon
Washington, D.C. 20310-0108

Re: State of Georgia's Water Supply Request

Dear Secretary Darcy:

On May 16, 2000, Governor Roy Barnes submitted to the Assistant Secretary of the Army for Civil Works a request that the U.S. Army Corps of Engineers allow withdrawals and make releases from Lake Lanier to meet Georgia's projected water supply demands of 705 million gallons per day (mgd). In 2012, after years of litigation, the Corps determined that it has the legal authority to grant Georgia's request. The Corps is now preparing an Environmental Impact Statement and will decide whether and how it will satisfy Georgia's request.

More than 3.3 million Georgians in the Metropolitan Atlanta area now rely on withdrawals or releases from Lake Lanier for water supply. Approximately six million people will rely on Lake Lanier for water supply by the year 2040. Lake Lanier is the most economical and environmentally-protective source of water supply for these Georgians. Operating Lake Lanier as Georgia has requested represents the highest and best use of Lake Lanier. I am confident that the Corps' EIS will concur in this assessment.

To assist the Corps in making its review based on the best and most current information available, I enclose with this letter an Affidavit by Judson H. Turner, Director of the Georgia Environmental Protection Division. Mr. Turner's Affidavit contains updated demographic and water demand data that confirm the continued need for the action Georgia has requested of the Corps, as well as updated analysis of the impact of granting Georgia's request on other project purposes and waters downstream. At a later date, Georgia also will submit an updated analysis of the national economic development benefits of granting Georgia's request.

As reflected in Mr. Turner's affidavit, based on current demographic information and as a consequence of improved water conservation, Georgia now 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. In addition, thanks to improved wastewater treatment, in most



months Georgia requires less flow than previously requested in the Chattahoochee River at the confluence with Peachtree Creek to meet applicable water quality standards.

To provide long-term certainty for all of those involved, Georgia continues to request that the Corps enter into agreements that document the parties' understanding as to how the Corps will operate in support of Georgia's water supply needs. We anticipate that for lake withdrawals that require allocation of storage, certainty will be provided in the form of storage contracts. For river withdrawals, which do not require an allocation of storage, other forms of agreement would be appropriate.

I ask that you act on Georgia's outstanding request at the earliest possible date. If you desire further information from Georgia, please let me know.

Sincerely,

A handwritten signature in black ink that reads "Nathan Deal".

Nathan Deal

cc: Colonel Donald E. Jackson, Commander, South Atlantic Division, U.S. Army Corps of Engineers
Colonel Steven J. Roemhildt, Commander, Mobile District, U.S. Army Corps of Engineers

Affidavit of Judson H. Turner

1. My name is Judson H. Turner. I am Director of the Georgia Environmental Protection Division (“EPD”) of the Georgia Department of Natural Resources.
2. In May 2000, the State of Georgia submitted to the Assistant Secretary of the Army for Civil Works a request for reallocation of storage in the Lake Lanier conservation pool to provide sufficient water supplies to meet future municipal and industrial water supply needs of 705 million gallons per day (mgd). In support of that request, Georgia provided an Affidavit from then-EPD Director Harold Reheis discussing Metropolitan Atlanta’s then-current and projected water supply needs and why Georgia needed a reallocation of storage in Lake Lanier to meet those needs. Georgia’s water supply request remains pending with the Corps. The purpose of this Affidavit is to provide updated data and information that are relevant to that request.
3. The State of Georgia is responsible for managing the quantity and quality of the waters of the State for public and private water supply, and for agricultural, industrial, and recreational uses, while protecting the environment and human health. Georgia law provides that “the government of the state shall assume responsibility for the quality and quantity of such water resources and the establishment and maintenance of a water quality and water quantity control program adequate for present needs and designed to care for the future needs of the state.” O.C.G.A. § 12-5-21(a).
4. EPD is the state agency to which state law delegates the responsibility for regulating withdrawals of water from, and discharges of pollutants into, the surface waters of the State. To fulfill this responsibility, EPD maintains data on the population of counties and municipalities within the State, and projections of the State’s future population growth and water needs. EPD’s expertise in hydrologic and water quality modeling allows it to assess the impact of water withdrawals and wastewater returns. EPD prioritizes water needs and evaluates alternatives for meeting these needs from the State’s finite water resources.

GEORGIA’S NEED FOR WATER SUPPLY FROM LAKE LANIER

Current Population and Projections for Future Growth

5. More than 3.3 million Georgians currently rely upon withdrawals of water directly from Lake Lanier or withdrawals of water that the Corps releases from Lake Lanier to the Chattahoochee River to meet their water supply needs. Attached as Appendix 1 is a table that identifies the counties within which municipal and industrial water use customers are dependent in whole or in part on withdrawals and releases from Lake Lanier for their water supply.
6. Also shown in Appendix 1 are projected populations of the counties that will depend on significant amounts of water from Lake Lanier in the future. EPD projects that the number of Georgians who depend upon Lake Lanier for water supply will rise to more than 6 million by around 2040. The numbers in Appendix 1 come from the last published projections of the Georgia Office of Planning and Budget (“OPB”). EPD also reviewed the last published

projections generated by the Metropolitan North Georgia Water Planning District (the “Metro Water District”).

7. Municipal water systems in six counties within the Chattahoochee River watershed above the confluence with Peachtree Creek currently withdraw water from the Lake Lanier/Chattahoochee River system. EPD projects that water systems in four additional counties that are riparian or tributary to Lake Lanier will depend upon withdrawals from Lake Lanier in the future. In addition, the following other counties rely on Lake Lanier for water supply: Bartow, Cherokee, Clayton, Douglas, Fayette, Henry, Paulding, Rockdale, and Walton.

8. Counties that rely on Lake Lanier for water supply comprise the majority of the population for the Atlanta Metropolitan Statistical Area (“MSA”), which, according to the U.S. Census Bureau, is the ninth largest MSA by population in the United States. From 2000 to 2010, the Atlanta MSA grew by 24%, a growth rate exceeded by only two other MSA’s in the United States. Two counties in the Atlanta MSA (Forsyth and Paulding) were among the 10 fastest growing counties in the United States during this period, both growing at rates greater than 74% for the decade. Gwinnett County added almost 217,000 persons to its population over the decade; for the same period, only 16 counties in the United States added more people.

Municipal and Industrial Water Supply Needs

9. Attached as Appendix 2 and Appendix 3 are the 2011 statistics for water withdrawals by the permit holders who rely upon the Lake Lanier/Chattahoochee River system. The average rate of water withdrawn directly from Lake Lanier in 2011 was 115.2 mgd. *See* Appendix 2. The annual average rate of water withdrawn from the Chattahoochee River between Buford Dam and Peachtree Creek was 245.7 mgd. *See* Appendix 3.

10. Appendix 4 shows projected withdrawals from Lake Lanier and the Chattahoochee River above the confluence with Peachtree Creek for the year 2040. EPD developed its forecasts for future water supply need projections in cooperation with the Metro Water District. These forecasts are based on a number of factors, including population, employment, and commercial and residential consumption rates.

11. EPD and the Metro Water District project that the nine local water systems that currently withdraw water from Lake Lanier or the Chattahoochee River above the confluence with Peachtree Creek will continue to do so. These systems are: City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, City of Cumming, Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta.

12. Of these, five systems – City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, and City of Cumming – withdraw from Lake Lanier. The other four facilities – Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta – withdraw from the Chattahoochee River upstream of the Peachtree Creek confluence. In

addition, EPD projects that Habersham, White, Lumpkin, and Dawson Counties in the future will need to withdraw approximately 41 mgd from Lake Lanier by 2040.

13. The Metro Water District's most recent Water Supply & Conservation Management Plan includes projections for municipal and industrial water supply needs for 2035 and 2050. Based on these projections, adding the 41 mgd of withdrawals by Habersham, White, Lumpkin, and Dawson Counties, and assuming that growth in water usage between 2035 and 2050 will be roughly linear, water supply needs that are dependent on withdrawals and special releases from Lake Lanier will meet or exceed 705 mgd on an annual average basis by 2040. This includes direct withdrawals from Lake Lanier of 297 mgd and withdrawals of 408 mgd from the Chattahoochee River below Buford Dam and above the confluence of the Chattahoochee River and Peachtree Creek.

14. Note that in calculating its water supply projections, the Metro Water District used a population growth rate for the region that is lower than the rate of growth that OPB has projected. Taking into account differing population projections and other variables affecting demand, EPD projects that municipal and industrial water supply demands that are dependent upon withdrawals and special releases from Lake Lanier will reach 705 mgd (including 297 mgd lake withdrawals and 408 mgd river withdrawals) sometime between 2035 and 2045. It is reasonable to plan using the assumption that Georgia's water supply needs will be at least 705 mgd by 2040.

15. In light of Georgia's projections that its water supply needs from Lake Lanier will equal or exceed 705 mgd by 2040, if not a few years sooner, Georgia's request of the Corps is unchanged from what was requested in 2000: that the Corps operate Lanier to accommodate withdrawals of up to 297 mgd annual average from Lake Lanier and 408 mgd annual average from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

16. Georgia plans to help meet demands from Lake Lanier with water that will be stored in the proposed Glades Reservoir upstream of Lake Lanier on Flat Creek, released to Flat Creek, and will flow into Lake Lanier to be withdrawn from one or several of the intakes in Lake Lanier. The Glades Reservoir currently is in the permitting process. Based on reasonable assumptions regarding operation of Glades Reservoir, EPD projects a 30-40 mgd yield from Glades Reservoir. EPD plans to work with the Corps and the reservoir sponsors to ensure that the Glades Reservoir serves as a net benefit to the system yield, provided that the Corps will be able to meet water supply needs of 705 mgd from Lake Lanier. Because the 30-40 mgd released from Glades Reservoir will be withdrawn from Lake Lanier at the same rate that it enters Lake Lanier, no storage should be required for the withdrawal of that water.

Water Conservation

17. The per capita water use rate in the Metropolitan Atlanta Region has fallen in recent years, and the projected demand the region assumes that per capita water use within the region will continue to fall. The use rate is currently 148 gallons per capita per day (gpcd), and is expected to decline to 135 gpcd by the 2035-2040 timeframe. The decline in per capita water use has and is expected to continue to result from implementation of aggressive state and local

water conservation policies, explained in greater detail below. Note that per capita water use and total population are among the factors, but are not the only factors, used to calculate total projected water use in the areas that are to be supplied by withdrawals and releases from Lake Lanier.

18. In 2001, the Georgia General Assembly created the Metro Water District and charged it with developing and maintaining comprehensive long-term plans for water supply and conservation, wastewater management, and watershed management for metro Atlanta. The Metro Water District is comprised of 15 counties, 92 cities, and 56 water supply systems. The plans are implemented by local water systems and local governments and are enforced by the State of Georgia through water permits and through eligibility for grants and loans. The Metro Water District completed development of its initial set of plans in September 2003. The governments within the Metro Water District spent the ensuing five years implementing the plans. In 2009, the Metro Water District adopted the first major update of its plans largely based upon lessons learned during the 2004-2009 implementation period.

19. Water conservation is an important element of the Metro Water District's Water Supply and Water Conservation Plan. The water conservation measures in the Plan are the most aggressive in Georgia and among the most aggressive in the United States. The 2003 Plan, as amended, included ten conservation measures applicable to all water systems and/or local governments. The 2009 update retained all and strengthened three of those measures. The Water Supply and Water Conservation Plan was again amended in December 2010 and added seven measures – two measures applicable throughout the District and five that apply to water systems that withdraw from Lake Lanier or the Chattahoochee River (denoted with asterisk). The water conservation measures in the Metro Water District Plan include: 1) conservation pricing; 2) replace older, inefficient plumbing fixtures; 3) pre-rinse spray valve retrofit education; 4) rain sensor shut-offs on new irrigation systems; 5) sub-unit meters in new multi-family buildings; 6) assess water losses with IWA/AWWA water audit methodology and develop programs to reduce systems water loss; 7) residential water audits; 8) low-flow retrofit kits for residential; 9) commercial water audits; 10) education and public awareness activities; 11) high-efficiency toilets and urinals in government buildings; 12) new car washes to recycle water; 13) expedited water loss reduction*; 14) multi-family HET rebates*; 15) meters with point of use leak detection*; 16) private fire lines to be metered*; 17) maintain a water conservation program*; 18) water waste policy or ordinance; and 19) HET plumbing fixtures in new construction consistent with state legislation.

20. The Metro Water District has made water conservation a priority, and local water systems have shown a strong record of implementation of water conservation measures. In annual progress surveys, the District has found: that tiered water conservation rates are in place throughout the metro area; that water systems serving 96% of the population offer toilet rebates, and over 76,872 older toilets have been replaced since 2008; that the larger systems have implemented programs to reduce system water losses, and, in 2010, over 10,000 leaks were repaired; and 98% of the population of the metro area is targeted with educational and outreach programs by local governments.

21. In 2010, the Georgia Water Stewardship Act was passed by the Georgia General Assembly and signed by Governor Sonny Perdue. For those water users relying on Lake Lanier and the Chattahoochee River above Peachtree Creek, the Water Stewardship Act amplified and supplemented the 19 water conservation policies and programs identified in the Metro Water District's water supply and conservation plan. Among the Act's provisions that supplement the Metro Water District's demand management initiatives are: 1) requiring state government agencies to examine their programs, practices, and rules to identify opportunities to provide for voluntary water conservation; 2) requiring local governments to include water conservation measures in local comprehensive plans; 3) incentives for public water systems to use full cost accounting; and 4) technical assistance to local governments and public water systems for water loss abatement activities.

22. In 2012, EPD conducted an evaluation of the 2000-2010 rates of growth in water demand compared to rates of population growth in the counties with the 15 largest municipal surface water systems in Georgia. Six of the 15 largest municipal surface water systems are located in five counties (i.e., Fulton, DeKalb, Cobb, Gwinnett, and Hall) that rely upon withdrawals or water supply releases from Lake Lanier. The evaluation showed that water use in each of the five counties demonstrated a consistent decreasing trend over the decade, while population in each of those counties increased over the decade. Trends such as these in the five counties and beyond clearly indicate that the water conservation initiatives being implemented in the Atlanta region by the Metro Water District are significantly reducing per capita water demand.

Crediting of Return Flows

23. EPD projects that returns of treated wastewater to Lake Lanier and tributaries immediately upstream of Lake Lanier will mitigate the effect of withdrawals from Lake Lanier. EPD projects that the average annual return of treated wastewater to Lake Lanier and its tributaries in 2040 (assuming withdrawals of 297 mgd) will be approximately 165 mgd. *See* Appendix 4. The net withdrawal from Lake Lanier is therefore expected to be 132 mgd (297 mgd minus 165 mgd).

24. The State of Georgia will allocate the treated wastewater returned to Lake Lanier and its tributaries to particular users of water supply storage in Lake Lanier. This should increase the yield of the storage account or accounts to which the wastewater return is credited rather than count the same as natural inflows, which increase the yield of a water supply storage account only according to the percentage of total conservation storage owned by that user.

25. I am aware of no legal or legitimate policy reason why the Corps should not credit metered return flows to Lake Lanier or its tributaries exclusively to individual water supply storage accounts to which the State of Georgia has allocated such returns.

26. In accordance with federal law, the Corps has long recognized that it is the State, not the Corps, that determines and allocates water rights, and that the Corps should defer to the State's allocation of water rights. Allocation of wastewater return flows to individual users also is a matter of water rights that is best determined by the State.

27. The return of highly-treated wastewater to an existing reservoir increases the yield of that reservoir by reducing the net withdrawals. As a result, return flows keep reservoir levels higher and mitigate the impact of water supply withdrawals. Return flows to a water supply reservoir are a form of water reuse that Georgia's statewide water plan favors.

28. EPD-permitted discharges from wastewater treatment plants are a function of water use and not rainfall and runoff, and therefore are more consistent and reliable than natural inflows. Because they are metered and reported to EPD, wastewater discharges also are easily monitored and accounted for, ensuring that a user would not obtain credit for any returns that do not actually occur.

29. It is more expensive for local wastewater utilities to discharge wastewater to Lake Lanier than to the Chattahoochee River or its tributaries, because they must treat the wastewater to a higher degree to meet applicable water quality standards. To make it worthwhile for these utilities to return wastewater to Lake Lanier, there must be policies in place that incentivize those returns. Therefore, EPD desires to credit to individual water users the exclusive right to withdraw or store the wastewater returns that are made. The Corps should do the same, or should defer to the State's allocation.

30. Thus, consistent with federal law and good policy, in determining the yield of the storage space that is held by or for a water supply user, the Corps should count exclusively to that user's storage space such returns as the State has allocated to that user.

Net Municipal and Industrial Water Consumption

31. A large portion of the metro Atlanta area's treated wastewater is returned to the Chattahoochee River downstream of Buford Dam and upstream of the United States Geological Survey ("USGS") gaging station at Whitesburg, Georgia. In 2011, an annual average of 34.4 mgd of treated wastewater was discharged to the Chattahoochee River between Buford Dam and the Peachtree Creek confluence, and an annual average of 184.2 mgd of treated wastewater was discharged to the Chattahoochee River between the Peachtree Creek confluence and the USGS Whitesburg gage. EPD projects that by 2040 (or as of the date when water withdrawals reach 705 mgd), the amount of treated wastewater discharged to the Chattahoochee River between Buford Dam and the Whitesburg gage will be 385 mgd on an annual basis, including 94 mgd discharged to the reach between Buford Dam and the Peachtree Creek confluence, and 291 mgd to the reach between the Peachtree Creek confluence and the USGS Whitesburg gage. When combined with return flow directly into Lake Lanier, the total return of wastewater associated with the withdrawal of 705 mgd is projected to be 550 mgd, or 78% of the total withdrawal.

32. Therefore, Georgia projects that as of 2040, the total consumptive use from municipal and industrial water supply from Lake Lanier and from the Chattahoochee River above the Whitesburg gage will be approximately 155 mgd, or 239 cfs, on an annual average basis. To put this amount into perspective, it is a mere 1.1% of the 21,587 cfs annual average daily flow of the Apalachicola River just downstream of the Georgia-Florida state line.

In-Stream Demands for Water Quality

33. Metropolitan Atlanta local governments that discharge treated wastewater to the Chattahoochee River also rely upon releases from Lake Lanier to provide consistent flows in the river to assimilate those discharges.

34. EPD has developed a mathematical model, known as the Chattahoochee River Model, to simulate temperature, dissolved oxygen, and the concentrations of individual pollutants (biochemical oxygen demand, organic nitrogen, ammonia, nitrate, organic phosphorus, and ortho phosphate) under different flow, intake, discharge, and meteorological conditions.

35. Based on conditions that existed at the time of Georgia's 2000 water supply request, EPD determined that certain seasonally-varying flows in the Chattahoochee River at the confluence with Peachtree Creek would be needed to meet water quality standards. Thanks to improvements in wastewater treatment since 2000, the Chattahoochee River Model now shows the flows needed to assimilate wastewater in the Chattahoochee River and maintain water quality standards may be reduced.

Why Assurance of Long-Term Supply is Needed Now

36. If Lake Lanier were not available to satisfy the needs included in Georgia's water supply request, additional reservoirs and water resource projects would be needed to replace it. Due to the complexity and uncertainty associated with the permitting processes, planning for the development of new water supply reservoirs must generally begin 15 to 25 years, or even more, before there is a demand for the water.

37. The three major stages of the planning processes are 1) alternatives analysis and source evaluation; 2) detailed engineering and environmental studies; and, 3) state and federal permitting. The first stage includes forecasting future service area population and water demands; evaluating demand management and supply alternatives for meeting the demands; evaluation of source water capacity, quality, and reliability; and development of environmental, historic/archeological, and socio-economic assessments of impacts. In the second stage, detailed engineering and environmental studies must be conducted on the preferred alternatives, and funding sources must be identified and secured. In the third stage, if a new or expanded water supply reservoir is the preferred alternative, the applicant must apply for and secure a Federal Clean Water Act Section 404 permit (issued by the Corps of Engineers), a Clean Water Act Section 401 Water Quality Certification (issued by the State of Georgia), a Safe Dams permit and a water withdrawal permit (both issued by the State of Georgia), and a Safe Drinking Water Act Permit (also issued by the State of Georgia). Before the Corps of Engineers can issue a Section 404 permit, it must comply with provisions of the National Environmental Policy Act (i.e., prepare an Environmental Assessment and possibly an Environmental Impact Statement) and federal regulations. Of all the stages, the Section 404 permitting process generally requires the greatest amount of time and often is followed by legal challenges to the issued permit. As shown in Appendix 6, the process of studying, designing, permitting, financing, and constructing water supply reservoirs in Georgia has required a range of 5 to 25 years to complete, based upon six cases selected for illustration.

38. Georgia desires assurance of storage for direct lake withdrawals through storage contracts. As for water supply releases, the Corps coordinates those with the Atlanta Regional Commission on a weekly basis. According to the 2011 ruling of the United States Court of Appeals for the Eleventh Circuit, the Corps is authorized to provide these releases without reallocating storage to those water supply users downstream. Nevertheless, to assure long-term certainty for all concerned, it is important that the Corps, Georgia, and local governments that Georgia may designate enter into a written agreement documenting their understandings regarding how and when releases for water supply will be coordinated.

Why Lake Lanier Continues to be the Best Alternative

39. As discussed in the Reheis Affidavit, numerous studies dating back to the 1960s have consistently concluded that Lake Lanier and the Chattahoochee River provide the most economical and environmentally-protective alternative for meeting the water supply needs of the region. See Reheis Affidavit at ¶¶ 21-28. As the Reheis Affidavit explains, a number of alternatives were investigated up through 1999, and none of them was determined to be a reasonable alternative. See *id.*

40. As part of the planning process for its 2003 plans and 2009 update, the Metro Water District considered potential water supply source alternatives for the communities in the study area through the planning period. The District's *Water Supply and Water Conservation Management Plan* determined that "after reviewing alternatives to the use of the federal reservoirs, the Metro Water District has concluded that there are no alternatives to the Chattahoochee River and the Etowah River as major water supply sources for north Georgia."

41. A water study task force, comprised of metro Atlanta area government and business leaders and assisted by Boston Consulting Group and technical experts, reached the same conclusion in 2009. The Governor of Georgia convened the task force, known as the Water Contingency Planning Task Force, in response to a decision of the United States District Court that threatened to eliminate virtually all water supply withdrawals and releases from Lake Lanier. The task force studied the costs associated with developing alternative sources of water resources to replace Lake Lanier if the Lake were to cease operating for water supply. The task force concluded that "Lake Lanier is by far the best water supply source for the metro region. If the recommended contingency options were required instead, these options would impose significant incremental costs and environmental impacts the region does not currently face." See *Water Contingency Planning Task Force Findings and Recommendations, 21 December 2009.*

IMPACT OF GEORGIA'S MUNICIPAL AND INDUSTRIAL WATER WITHDRAWAL ON LAKE LANIER AND WATERS DOWNSTREAM

42. EPD has performed computer modeling of the reservoir operations and water withdrawals contemplated in Georgia's water supply request to determine the effects of those operations and withdrawals on Lake Lanier and the Chattahoochee River. EPD's modeling is summarized below and discussed in greater depth in Exhibit A, the Memorandum of Dr. Wei Zeng, manager of EPD's Hydrological Analysis Unit. Although Dr. Zeng, for the purpose of his analysis, assumed that the Corps will continue to operate in accordance with the current version

of the Revised Interim Operation Plan (“RIOP”), the State of Georgia continues to believe that the ACF system can be operated more efficiently for the benefit of all Basin stakeholders and is proposing alternative to the RIOP in our comments on the ACF Water Control Manual EIS Scoping Comments.

Hydropower Production at Lake Lanier and within the ACF System

43. The projected water withdrawals and Corps operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam or the federal reservoirs in the ACF Basin as a whole, and any impact will be gradual over the next several decades. EPD’s modeling indicates that, if viewed in terms of hydropower generation for the federal reservoirs in the ACF Basin as a whole, when Georgia has reached demands of 705 mgd and year 2040 water supply needs are met throughout the rest of Georgia, average annual power generation will be 970,900 MWh, as compared with the 988,055 MWh of (simulated) annual average generation with 2011 water supply levels. Thus, EPD projects a mere 1.7% decrease in hydropower generation basin-wide. *See Zeng Memorandum at Exhibit A.*

44. When Georgia has reached demands of 705 mgd from Lanier and the Chattahoochee River above the Peachtree Creek confluence, and 2040 water supply demands exist throughout the remainder of the basin, the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh, in comparison to the amount of 123,735 MWh under 2011 water use conditions. Thus, the amount of hydropower produced at Lake Lanier with 2040 demands will be only 6% less than the amount being produced with current water supply demands. The effect will be even less in the years before Georgia’s water demand has reached 705 mgd. *See Zeng Memorandum at Exhibit A.*

45. Georgia’s conclusions are consistent with those reached by the Corps in its assessment of the impact to hydropower from granting Georgia’s water supply request as compared with a baseline that assumed virtually no water supply operations at all. Using that baseline of comparison, the Corps concluded that the water supply operations and lake withdrawals would result in less than a 1% reduction to ACF Basin dependable hydropower capacity, and that the lake withdrawals and water supply releases contemplated by Georgia’s water supply request would result in reductions in basinwide hydropower value of 4.4% and less than 1%, respectively. *See Zeng Memorandum at Exhibit A.*

Recreation at Federal Reservoirs

46. The Corps has established three thresholds for assessing impact of reservoir elevation to recreation at Lake Lanier. The first threshold is called Initial Recreation Impact Level (“IIL”), which is the level at which falling reservoir elevation first has some adverse effect on recreation. The Corps has determined that the IIL at Lake Lanier is 1066 feet above mean sea level (msl). The second threshold, the Recreation Impact Level (“RIL”), is the level at which significant impacts to concessions and recreation occurs. The RIL at Lake Lanier is 1063 feet above msl. The third threshold is Water Access Limitation Level (“WAL”), which is the elevation at which more serious impacts to recreation are observed. The WAL at Lake Lanier is 1060 feet above msl.

47. As discussed at greater length in the attached Memorandum of Wei Zeng, under 2007 hydrologic conditions, with existing water supply demands, Lake Lanier is below RIL for 27 days during the primary recreational season in that year (May 1-September 8). EPD's modeling shows that this level of recreation impact will be increased by only 21 days under 2007 hydrologic conditions if Lanier is operated to meet the metro area's 2040 water needs of 705 mgd and Georgia's 2040 water supply needs in the remainder of the basin exist. EPD's modeling also shows that if Lanier is operated to meet Georgia's water supply request, metro area water supply needs from Lake Lanier reach 705 mgd, and 2040 water demands exist elsewhere in the basin, during the recreational season, the elevation of Lake Lanier would be below the ILL for only 5% more of the time, below the RIL for only 8% more of the time, and below the WAL 8% more of the time, than under the baseline condition. See Zeng Memorandum at Exhibit A.

48. At West Point Lake, the Corps has designated a ILL of 632 feet above msl, a RAL of 628 feet above msl, and a WAL of 627 feet above msl. If Lake Lanier is operated to meet water supply needs of 705 mgd, the number of days when West Point Lake falls below the RIL and ILL actually will be lessened, and there will be only a 1% increase in the number of days in which the elevation falls below the WAL.

49. For Lake Walter F. George, the ILL is 187 feet above msl, the RAL is 185 feet above msl, and the WAL is 184 feet above msl. With 2040 water supply demands imposed on the system, Lake Walter F. George will not experience elevations below RIL or WAL, and will see an increase of only 1% to 2% in the number of days below the ILL. See Zeng Memorandum at Exhibit A.

Navigation

50. As the ACF Basin reservoirs, for reasons unrelated to Georgia's water supply usage, are no longer used to support commercial navigation except under rare circumstances, Georgia's water supply request will not impact navigation.

Lake Lanier's Flood Control Function

51. The current request to reallocate the conservation storage to meet Georgia's projected future water supply needs does not involve changing the elevation of the top of conservation pool or the size of the flood control pool. Thus, reallocating part of the conservation storage to accommodate Georgia's increase water will have no impact on the flood control capability of Lake Lanier or the ACF system. Although changes to the size of the flood control pool are not necessary for the Corps to grant Georgia's request, Georgia may still recommend raising the conservation pool, at the appropriate time, if and when it determines that the benefits of doing so exceed any costs.

Impacts on Georgia/Florida State Line Flows

52. EPD's modeling indicates that the net water consumption associated with the municipal and industrial withdrawals contemplated in Georgia's water supply request is projected to have a

minor impact on the flow in the Apalachicola River at the state line. See Zeng Memorandum at Exhibit A.

CONCLUSION

53. The foregoing information affirms and updates Georgia's 2000 request that the Corps operate Lake Lanier to meet water supply needs of 705 mgd annual average gross withdrawal, including 297 mgd annual average gross withdrawal from Lake Lanier and 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence of the Chattahoochee River and Peachtree Creek. Accordingly, the Governor of Georgia has asked that the Corps grant Georgia's request by taking the following actions:

(a) Accommodate water supply demands by providing for 297 mgd annual average gross withdrawal from Lake Lanier and by making releases to allow 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

(b) Provide certainty for those municipal and industrial water withdrawals from Lake Lanier that require an allocation of storage by entering into long-term contracts. No storage should be required for withdrawals covered by existing relocation contracts or withdrawals of water released to Lake Lanier from Glades Reservoir upstream. Returns to Lake Lanier or its tributaries of treated wastewater should be credited exclusively to the storage accounts of those whom Georgia EPD designates to receive such credit.

(c) Provide certainty for those municipal and industrial water withdrawals from the Chattahoochee River that rely upon special releases from Lake Lanier by entering into agreements that document the parties' understandings about assurance and coordination of releases.

(d) Release from Lake Lanier enough water to provide a flow in the Chattahoochee River at the confluence with Peachtree Creek as EPD may request to maintain applicable water quality standards.

FURTHER AFFIANT SAITH NOT.

This 10th day of January, 2013.

Sworn to and subscribed
before me this 10th day
of January, 2013

Yolanda P. Fanning

Notary Public

My commission expires: *Sept 29, 2013*



Judson H. Turner

Judson H. Turner

APPENDIX 1

Historical and Forecasted Population of Counties Using Lake Lanier System for Water Supply

County	1990 ¹	2000 ¹	2010 ¹	2020 ²	2030 ²	2040 ³
Cobb	447,745	607,751	688,078	800,469	909,747	1,033,943
Dawson ⁴	9,429	15,999	22,330	27,029	32,022	37,937
DeKalb	545,837	665,865	691,893	761,537	817,276	877,096
Forsyth	44,083	98,407	175,511	256,307	383,258	573,089
Fulton	648,951	816,006	920,581	1,095,897	1,284,954	1,506,626
Gwinnett	352,910	588,448	805,321	1,019,098	1,270,020	1,582,724
Habersham ⁴	27,621	35,902	44,553	48,705	54,623	61,260
Hall	95,428	139,277	179,684	226,172	282,164	352,018
Lumpkin ⁴	14,573	21,016	29,966	38,075	47,960	60,411
White ⁴	13,006	19,944	26,704	31,057	34,841	39,086
Totals ⁵	2,199,583	3,008,615	3,584,621	4,273,267	5,116,865	6,127,000

¹From US Census Bureau

²Georgia Office of Planning and Budget 2012 Projections

³Projection based upon assumption that 2030 – 2040 growth rate (in per cent) will be same as 2020 – 2030.

⁴Watershed counties not currently withdrawing from Lanier, but may withdraw in future.

⁵This total does not include the additional counties that purchase water from the water systems that withdraw water from Lake Lanier and the Chattahoochee River, such as Paulding County.

APPENDIX 2

Water Systems That Withdraw Directly from Lake Lanier

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Annual Average
Forsyth	City of Cumming	17.5	18.8	11.6
Forsyth	Forsyth County	11.8	12.8	8.6
Gwinnett	City of Buford	1.5	1.7	1.3
Gwinnett	Gwinnett County Water & Sewerage Authority	90.9	118.8	76.1
Hall	City of Gainesville	20.7	28.5	17.6
Total				115.2

APPENDIX 3

Water Systems That Rely on Water Supply Releases from Lake Lanier to the Chattahoochee River

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Average Annual
Cobb	Cobb County Marietta Water Authority	51.9	64.8	45.1
DeKalb	DeKalb County Public Works (Water and Sewer)	84.7	114.8	72.7
Fulton	Atlanta – Fulton Water Resources Commission	54.3	69.9	38.7
Fulton	City of Atlanta	101.8	123.4	89.2
Total				245.7

APPENDIX 4

Projected 2040 Water Withdrawals and Returns

(Annual Average)

Table 1 Current and Projected 2040 Water Withdrawals and Returns Above Buford Dam

Time Horizon	Withdrawal (mgd)	Return (mgd)	Net Consumptive Loss (mgd)
2011	120.6 ¹	38.1	82.4
2040	297	165	132

Table 2 Current and Projected 2040 Chattahoochee River Water Withdrawals and Returns

Time Horizon	Withdrawal (mgd) (Buford Dam to Peachtree Creek)	Return (mgd)			Net Consumptive Loss (mgd)
		Atlanta Reach (Buford Dam to Peachtree Creek)	Whitesburg Reach (Peachtree Creek to Whitesburg gage)	Total	
2011	247.5 ²	34.5	185.3	219.8	27.7
2040	408	94	291	385	23

Notes:

¹ Including facilities upstream of Lake Lanier. These additional withdrawals are included to provide the sum of all consumptive loss above Buford Dam.

² Including facilities that withdrew from tributaries of the Chattahoochee River. These additional withdrawals are included to provide the sum of all consumptive loss below Buford Dam and above the Whitesburg gage.

APPENDIX 5

TIME REQUIRED TO PLAN, PERMIT, FINANCE, AND CONSTRUCT WATER SUPPLY RESERVOIRS IN GEORGIA [Note: Try to fit all on one page]

Project Activity	Bear Creek Reservoir, Jackson Co.	Cedar Creek Reservoir, Hall Co.	Tussahaw Creek Reservoir, Butts Co.	Big Haynes Creek Reservoir, Rockdale Co.	Line Creek Reservoir (Lake McIntosh), Fayette Co.	Hickory Log Creek Reservoir, Cherokee Co.
Applicant's initial contact with EPD regarding a new reservoir.	2/2/1994	7/17/1996	9/22/2000	11/5/1987	10/27/1987	3/22/2000
Applicant initial contact with the Corps regarding 404 permit for reservoir.	2/2/1994	2/12/1997	9/22/2000	4/29/1991	1/6/1989	3/22/2000
Applicant submits water withdrawal permit application.	3/3/1997	4/2/2002	3/13/2001	6/21/1999	3/21/2001	10/4/2005
EPD comments on withdrawal application.	5/28/1997	4/22/2002	5/22/2001	12/7/1999	4/16/2001	11/22/2005
EPD provides confirmation of need (to the Corps).	4/20/1995	Information unavailable	11/3/2000	5/6/1991	11/20/2000	11/20/2000
Applicant submits 404 application to the Corps.	2/22/1995	8/26/1997	11/15/2000	5/28/1991	5/1/2002	4/27/2000
The Corps notifies public of the 404 application and requests comments.	5/26/1995	10/8/1997	12/27/2000	11/22/1991	10/3/2002	12/27/2000
The Corps responds to applicant's 404 application.	7/1/1995	11/13/1997	2/1/2001	12/28/1991	11/8/2002	2/28/2001
EPD issues 401 Water Quality Cert.	5/17/1996	8/21/1998	5/22/2001	8/31/1992	9/6/2006	8/2/2002
EPD issues withdrawal permit.	4/1/2002	8/1/2002	2/14/2003	3/22/2002	9/6/2006	9/12/2008
The Corps issues final 404 permit to applicant.	7/20/1996	11/16/1998	10/23/2002	10/2/1992	6/27/2007	5/24/2004
EPD issues Safe Dams permit.	10/1999	10/2001	8/25/2003	5/31/1994	12/9/2009	4/29/2008

Jurisdiction constructs dam.	04/2001	9/11/2003	June 2005	1/27/1997	April 2010	8/5/2005
Jurisdiction fills reservoir.	Spring 2002	8/11/2005	Sept. 2005	June 1998	Started November 1, 2012	6/30/2011

EXHIBIT A

**Memorandum of Dr. Wei Zeng
Manager, Hydrologic Analysis Unit**

Georgia Department of Natural Resources
Environmental Protection Division

Watershed Protection Branch
4220 International Pkwy., Suite 101, Atlanta, Georgia 30354
Linda MacGregor, P.E., Branch Chief
(404) 675-6232

Memorandum

To: Judson Turner, Director, Georgia EPD
From: Wei Zeng, Hydrology Unit, Georgia EPD
Date: January 10, 2013
Subject: Technical Analysis of Georgia's 2000 Water Supply Request

Introduction

You asked me to analyze the impact to the federal reservoirs in the Apalachicola-Chattahoochee-Flint (ACF) River Basin, to hydropower production and recreation at those reservoirs, and to river flows at the state line with Florida, of Georgia's 2000 Water Supply Request. Georgia submitted the water supply request to the U.S. Army Corps of Engineers in May 2000, asking for the Corps to operate Lake Lanier to accommodate future municipal and industrial direct withdrawals from Lake Lanier and river withdrawals downstream totaling 705 million gallons per day (mgd). As more than twelve years have passed since Georgia submitted its water supply request to the Corps, Georgia is providing the Corps updated demographic and water demand information in support of its request. Georgia forecasts that its municipal and industrial water supply demands from Lake Lanier will reach or exceed 705 mgd by approximately 2040.

The Hydrology Unit of EPD set up a mathematical model of the ACF Basin to analyze the potential impacts of Georgia's request. This memorandum documents the model settings and results.

Platform Model – HEC-ResSim

The mathematical model that we used for this analysis was developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) for analyzing reservoir operations and basin-wide water resource management. The Corps calls this platform model "HEC-ResSim." The Corps periodically upgrades HEC-ResSim's capability. The Corps released its current version of the model to the public in May 2011. This version of the model reflected the Corps' then-current ACF Basin reservoir operating plan, known as the Revised Interim Operation Plan (RIOP), as it existed as of May 2011.

Since May 2011, the Corps has made minor changes to the RIOP. The Hydrology Unit of EPD has added these changes to the Corps' May 2011 platform model. Thus, EPD's version of the HEC-ResSim model reflects operations under the current RIOP.

We modeled a 34-year period, assuming rainfall and inflow conditions that occurred from January 1, 1975 to December 31, 2008, and applied to each of these years the Corps' RIOP and, as discussed below, varying levels of water supply use. We chose the 1975-2008 period for several reasons. First, the Unimpaired Flow (UIF) data developed by the Corps only covers hydrologic conditions through December 31, 2008. In addition, this period excludes the period before all ACF federal reservoirs have been in operation. Finally, the U.S. Fish and Wildlife Service has used the same simulation period for its analyses of various ACF operations. It should be noted that the droughts

that most affected the federal reservoirs in the ACF Basin occurred within in this period, with the possible exception of the current drought, the duration and severity of which cannot yet be determined.

Model Setting on Water Demand

To understand the impacts of Georgia's water supply request, we compiled current and proposed future water use conditions and ran three different scenarios: what we call Baseline Condition, Scenario A, and Scenario B. The Baseline Condition assumes current water use, as further defined below. Scenario A isolates the effect of the withdrawals associated with Georgia's water supply request by applying to the model annual average gross withdrawals of 705 mgd from Lake Lanier and the Chattahoochee River through Atlanta but keeps current demands throughout the remainder of the ACF Basin. Scenario B evaluates the effects of the water use contemplated in Georgia's water supply request in combination with forecasted demands throughout the basin by assuming annual average gross withdrawals of 705 mgd from Lake Lanier and the Chattahoochee River through Atlanta and year 2040 water use throughout the remainder of the ACF Basin in Georgia, plus increasing water use in ACF Basin in Alabama, as discussed further below.

Baseline Condition

To capture the effect of current water use within the ACF Basin, we included in the model the most recent available annual (2011) withdrawal and discharge data of all permitted municipal and industrial facilities in the Georgia portion of the ACF Basin. These include thermal electric power generating facilities that use water for cooling purposes and that incur consumptive water losses as a result of their cooling operations. We included the estimate of 2007 total ACF Basin agricultural water use that Georgia developed as part of its statewide water planning, which is the best information that we have on Georgia's current agricultural use.

We included Alabama's 2007 water consumption from the ACF Basin as estimated by the Alabama Office of Water Resources (OWR) in 2009. For water consumption in Florida, we used the numbers contained in the Corps' platform model.

In the Baseline Condition, and in Scenarios A and B, we assumed the current RIOP would remain in effect.

Scenario A – Impact of Water Supply Request

As Georgia's water supply request remains 297 mgd annual average gross lake withdrawal and 408 mgd annual average gross river withdrawal, for a total of 705 mgd, those are the amounts of withdrawal that we used in the impact analysis. We added back projected returns of treated wastewater to Lake Lanier and the Chattahoochee River. Using EPD projections, we assumed that 78% of the 705 mgd that is withdrawn will be discharged back to surface waters within the basin in the form of highly treated wastewater. This includes 165 mgd returned to Lanier and its upstream tributaries, 94 mgd returned to the Chattahoochee River between Buford Dam and Peachtree Creek, and 291 mgd returned to the Chattahoochee River downstream of Peachtree Creek.

As Scenario A is intended to isolate the impact of meeting the forecasted water supply needs that would be dependent on withdrawals and water supply releases from Lake Lanier, we held water use elsewhere in the basin at current levels (that is, levels according to most recent data available).

Scenario B – Impact of Water Supply Request in Combination with Other 2040 Georgia Demands in ACF Basin

In Scenario B, we added to the water supply uses contemplated by Georgia's water supply request the other projected 2040 water demands within the ACF Basin in Georgia. These include projected municipal, industrial, and agricultural water needs. EPD developed the forecasts for those demands as part of the planning associated with the State Water Plan and Regional Water Development Plans. We do not have projected water demands for portions of the basin that are in Alabama. To estimate the cumulative impact resulting from future Alabama demand, we assumed an increase of 15% to the current Alabama figure used in the baseline condition alternative. We held the level of water use in the Apalachicola River reach the same as in the Baseline Condition because we have no information upon which to base an estimate of future water use in the State of Florida. I have enclosed a DVD containing these models.

Results and Analysis

In my discussion of the modeling results, Scenarios A and B are compared to the Baseline Condition. The potential impact of Georgia's Request is described with regard to:

- (1) Average elevations in the federal reservoirs of Lanier, West Point, and Walter F. George;
- (2) Minimum elevations in these reservoirs;
- (3) Elevation duration curves in these reservoirs;
- (4) Daily average power generation in the federal reservoirs;
- (5) Percentage of time when there is some level of recreational impact; and
- (6) State line flow duration curve.

Reservoir Elevations

Using the Res-Sim Model, we determined the average and minimum daily elevations, and the elevation duration curves, of the federal reservoirs in the ACF Basin under the Baseline Condition and Scenarios A and B. The average and minimum daily elevations of a reservoir are obtained by looking at the daily elevation of the period of simulation, from January 1, 1975 to December 31, 2008, and calculating the average and minimum daily value for each of the 365 days in a year. The elevation duration curve shows the percentages of time over the entire 34-year period that the reservoirs will exceed certain elevations.

As shown in Slides 9 and 25 of the attached Exhibit 1, the average daily elevation of Lake Lanier under both Scenarios A and B will be no more than 0.7 feet lower around May 1 as compared with the Baseline Condition. May 1 is the date on which the top of conservation pool guide curve for Lake Lanier rises to 1071 feet for the first time in the year and is the beginning of the primary recreational season. Similarly, the average daily elevation of Lake Lanier around December 1 under Scenarios A and B is no more than 1.5 feet lower than under the Baseline Condition.

The difference between the Baseline Condition and Scenarios A and B is more pronounced in terms of the daily minimum elevation in Lake Lanier. (See Slides 10 and 26.) At the lowest point on the minimum daily elevation curve, which usually takes place in the month of December, the elevation under Scenarios A and B is approximately 6 feet lower than in the Baseline Condition.

The elevation duration curves for Lake Lanier are shown on Slides 11 and 27. For the upper 30% of the duration curve (representing the times of higher reservoir elevation), the elevation of Lake Lanier is essentially the same in the Baseline Condition and Scenarios A and B. Moreover, for approximately 70% of the duration curve, the elevation under Scenarios A and B is only approximately one foot or less lower than in the Baseline Condition. The difference is greater, up to 6 feet, at the lowest point in the lower 30% of the duration curve.

The impact on Lakes West Point and Walter F. George is minor. (See Slides 12 through 17 and Slides 28 through 33.) There is very little, only inches, difference in average daily elevation at both West Point and Walter F. George between the Baseline Condition and Scenarios A and B. In terms of minimum daily elevation, the greatest difference between the Baseline Condition and Scenarios A and B is only 1.5 feet in West Point (in the months of September and October), and up to 1.2 feet at Walter F. George (in September and October). At the point in the year when West Point and Walter F. George typically reach their lowest elevation for the year (usually in November or December), there is little difference between the Baseline Condition and Scenarios A and B. Even less of a change is evident in the elevation duration curves for Lakes West Point and Walter F. George. (See Slides 14, 17, 30, and 33).

Power Generation

The projected water withdrawals and Corps operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam. Under Scenario A, with water supply needs of 705 mgd for the Metro Atlanta Area and current demands elsewhere, the daily average energy generated at Lake Lanier is modeled to be 319 MWh, and the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh. In comparison, the daily average energy generated under the Baseline Condition is modeled to be 339 MWh and the annual average is 123,735 MWh. When Georgia has reached demands of 705 mgd from Lake Lanier and the Chattahoochee River above the Peachtree Creek confluence, combined with 2040 water supply demands throughout the remainder of the basin, the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh, in comparison to 123,735 MWh under the Baseline Condition. Thus, assuming 2040 water supply demands throughout the ACF Basin, there would be less than a 6% reduction in power produced at Lanier. The impact will be even less in the years before Georgia's water demand has reached 705 mgd.

As shown by Slides 18 and 34, Georgia's future water supply demands will have very little impact on the total amount of energy produced by all of the federal reservoirs in the ACF Basin. Under Scenario A, when Georgia has reached demands of 705 mgd, the daily average energy output from all ACF federal reservoirs is modeled to be 2,671 MWh (annual average 974,915 MWh). The daily average energy output under the Baseline Condition is 2,707 MWh, and the annual average is 988,055 MWh. Thus, there will be only a reduction in daily average generation of 36 MWh (annual average reduction of 13,140 MWh) for all reservoirs combined. Under Scenario B, the daily average energy output from all ACF federal reservoirs is modeled to be 2,660 MWh (annual average 970,900 MWh). The reduction in daily average generation will be only 47 MWh (annual average reduction of 17,155 MWh). For the combined generation of all of the federal reservoirs in the ACF Basin, there is only a 1.3% reduction under Scenario A and a 1.7% reduction under Scenario B.

Georgia's conclusions are consistent with those reached by the Corps in its assessment of the impact to hydropower from granting Georgia's water supply request as compared with a baseline that assumed virtually no water supply operations at all. Using that baseline of comparison, the Corps concluded that the water supply operations and lake withdrawals under Georgia's water supply

request each would result in less than a 1% reduction to ACF Basin dependable hydropower capacity; that the lake withdrawals contemplated by the request would result in a reduction in basin-wide hydropower value of 4.4%; and, that the water supply releases contemplated by the request would result in a reduction in basin-wide hydropower value of less than 1%.

Recreational Impact

We evaluated the recreational impact by looking at the primary recreational season, defined by the Corps as May 1st through September 8th, and tallying the percentage of days when elevation of a reservoir is lower than the three levels of recreational impact, which are, in increasing degree of impact, the Initial Impact Line (IIL), Recreational Impact Line (RIL), and Water Access Limitation (WAL). According to the Corps, the IIL at Lake Lanier is 1066 feet above mean sea level (msl), the RIL is 1063 feet above msl, and the WAL is 1060 feet above msl. For West Point Lake, the IIL is 632 feet above msl, RAL is 628 feet above msl, and WAL is 627 feet above msl. For Lake Walter F. George, the IIL is 187 feet above msl, the RAL is 185 feet above msl, and the WAL is 184 feet above msl.

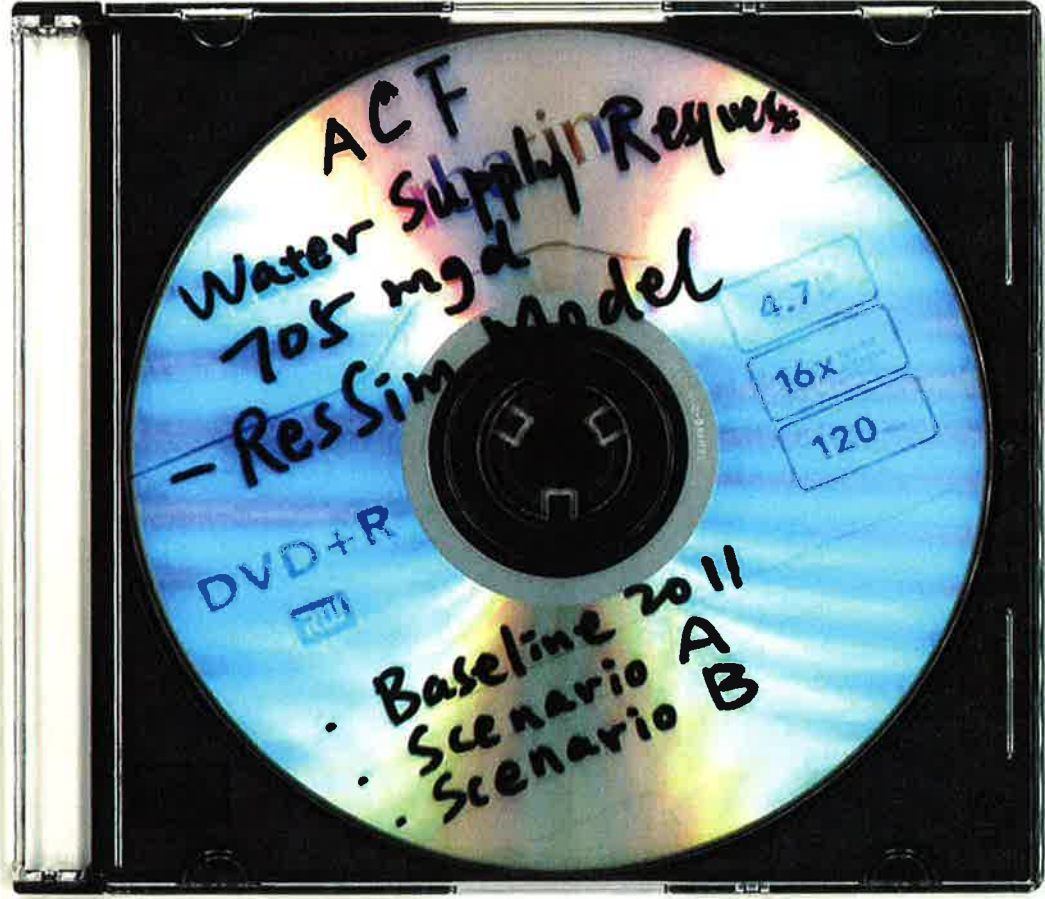
The impact to recreation is shown on Slides 19 through 21 and 35 through 37. In Scenarios A and B as compared with the Baseline Condition, the increase in percentage of days of IIL, RIL, and WAL at Lake Lanier will be 5%, 8%, and 8% respectively. Under hydrologic conditions of Year 2007, a drought year of exceptional dry conditions, the total number of days when the elevation of Lanier falls below the RIL under Scenario A is 47 days, under Scenario B is 48 days, and under the Baseline Condition is 27 days.

The recreational impact on West Point and Walter F. George is virtually non-existent. The only impact on West Point under Scenario A and Scenario B is a 1% increase in the frequency of WAL, while the recreational impact of IIL and RIL actually are lessened. At Walter F. George, there is a 1% and 2% increase in IIL in Scenario A and Scenario B, respectively. The elevation of Walter F. George does not fall to the RIL or WAL in any of the three scenarios.

State Line Flow

There is no noticeable difference between Scenario A and the Baseline Condition alternative in terms of state line flow duration curve, which suggests that the isolated increase in water supply in the metro Atlanta area itself will not result in any significant change in state line flow. (See Slides 22 and 23.) When we look at the portion of the graph between the 80 and 95 percentiles exceedence, the curve resulting from Scenario B is only around 200 cfs below the curve resulting from the Baseline Condition. (See Slides 38 and 39.) This 200 cfs is only 4% of the minimum flow requirement of 5,000 cfs, and less than 1% of the long term average simulated flow. At the very bottom of the duration curve, note that the RIOP's Drought Zone Operation will be triggered roughly 0.2% of the time under Scenario A and only 0.2% more often under Scenario B. Overall, the change in state line flow is minor in comparison to the magnitude of state line flow assuming the RIOP remains in place, and will likely remain so in any new operation plan that replaces the RIOP.

Enclosure



ACF
Water Supply Request
705 mgd
- Res Sim Model

DVD+R

- Baseline 2011
- Scenario A
- Scenario B

4.7
16x
120

ACF Water Supply Request Evaluations

Georgia EPD

Hydrology Unit

January 2013

Model Scenarios

- **Baseline**
 - Recorded 2011 M&I and thermal water use
 - Estimated 2007 Agricultural water use
 - 2007 Alabama reach-wise (Columbus, WFG, and Jim Woodruff reaches) water use as provided in UIF data
 - May 2011 version ACF ResSim model
 - RIOP operation as revised and reflected in May 2012 Biological Opinion

Model Scenarios

- Scenario A
 - Projected 2040 Metro District (Atlanta area) water use as revised from 2009 Metro District Plan
 - Water use conditions held unchanged in the other reaches
 - May 2011 version ACF ResSim model
 - RIOP operation as revised and reflected in May 2012 Biological Opinion

Model Scenarios

- Scenario B
 - Projected 2040 Metro District (Atlanta area) water use as revised from 2009 Metro District Plan
 - Projected 2040 water use for the other reaches per State Water Plan
 - Alabama 2007 use water with a 15% increase
 - May 2011 version ResSim model
 - RIOP operation as revised and reflected in May 2012 Biological Opinion

Modeled 2040 Metro District Water Demand

- **Withdrawal**
 - 297 mgd in Lanier reach including 256 mgd from metro District entities and 41 mgd reserved for upstream entities
 - 408 mgd in the upper Chattahoochee River
- **Return**
 - 165 mgd to Lanier
 - 94 mgd to Chattahoochee River between Buford Dam and Peachtree Creek
 - 291 mgd to Chattahoochee River between Peachtree Creek and Whitesburg gage

Period of Simulation

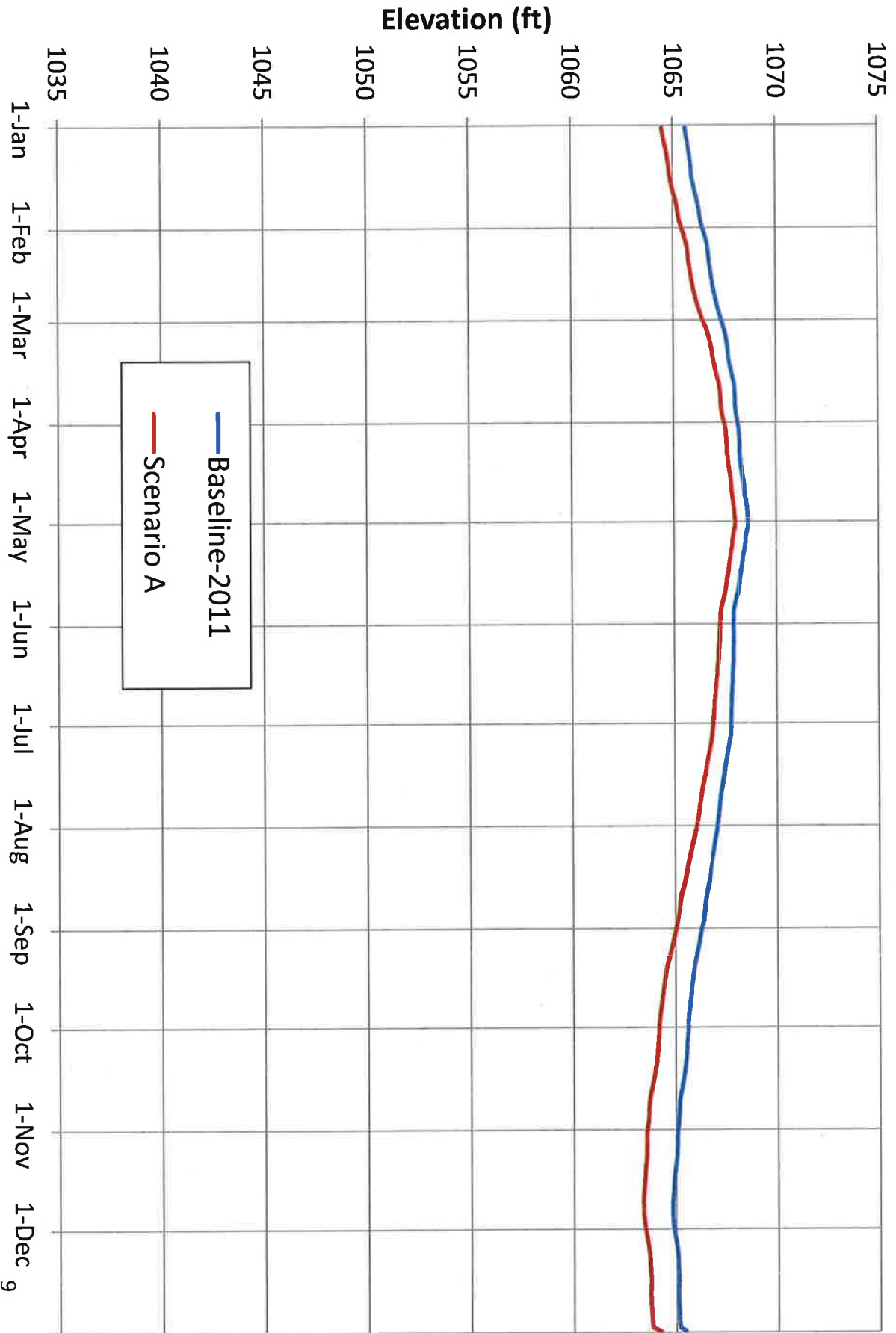
- January 1, 1975 through December 31, 2008
- Corresponding to period when all federal reservoirs are in place
- Period containing the most severe droughts in the past three decades
- Corresponding to the period used by USFWS for alternative evaluations

Modeling Results

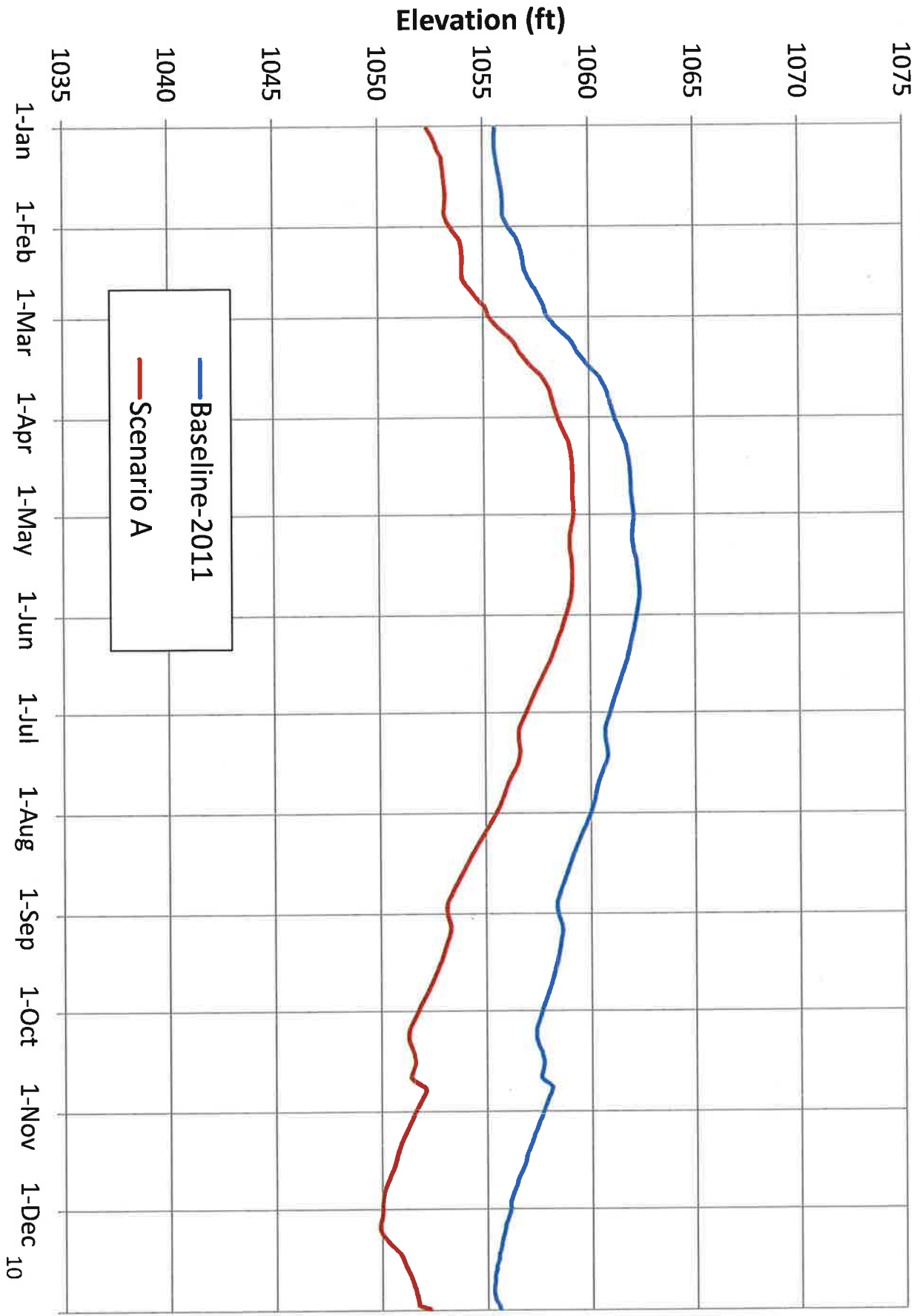
- Average lake elevations
- Minimum lake elevations
- Lake elevation exceedance
- Average power generation
- Recreation impacts
- State line flow

Scenario A vs. Baseline

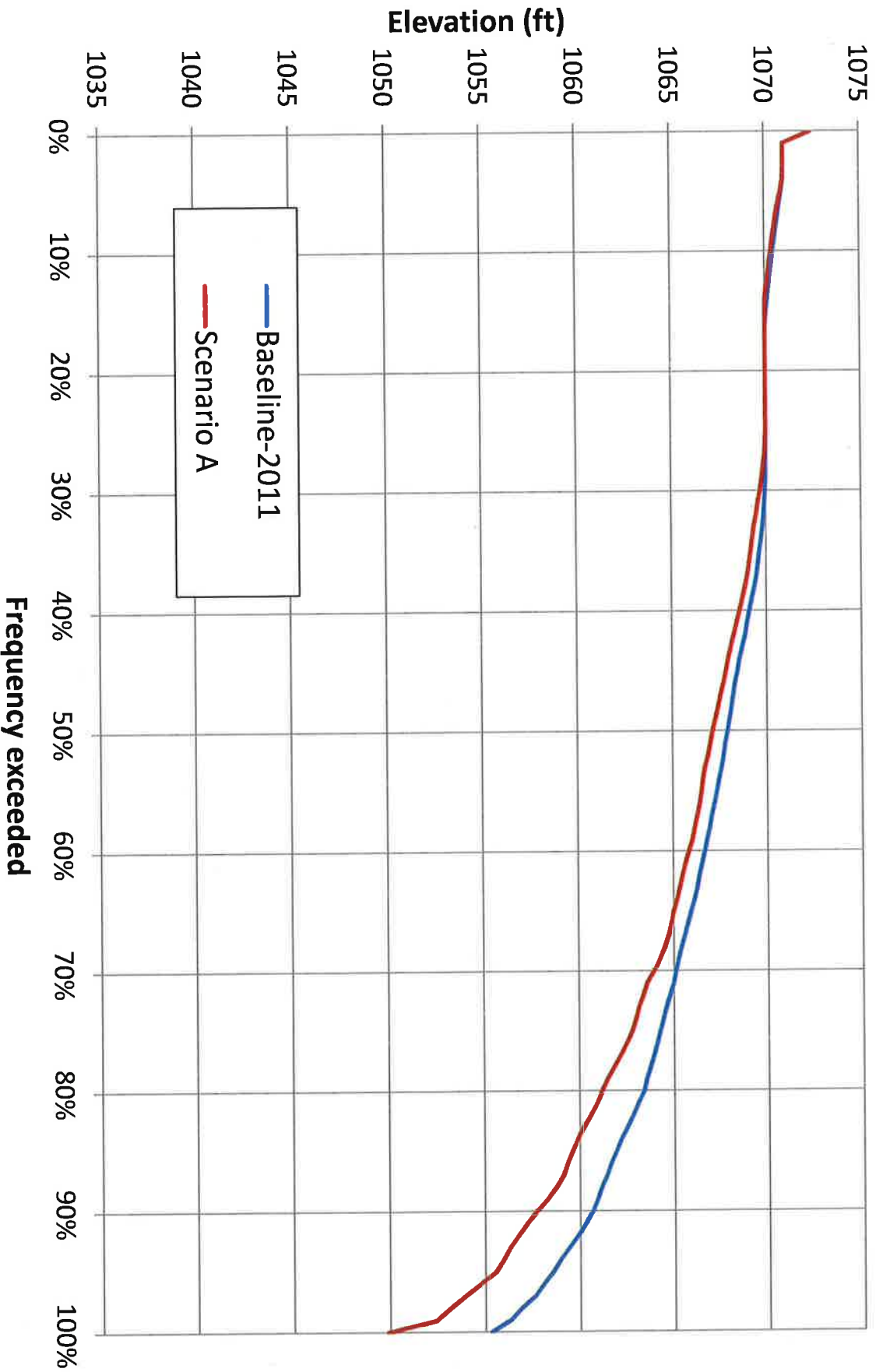
Simulated Average Daily Elevation at Lanier



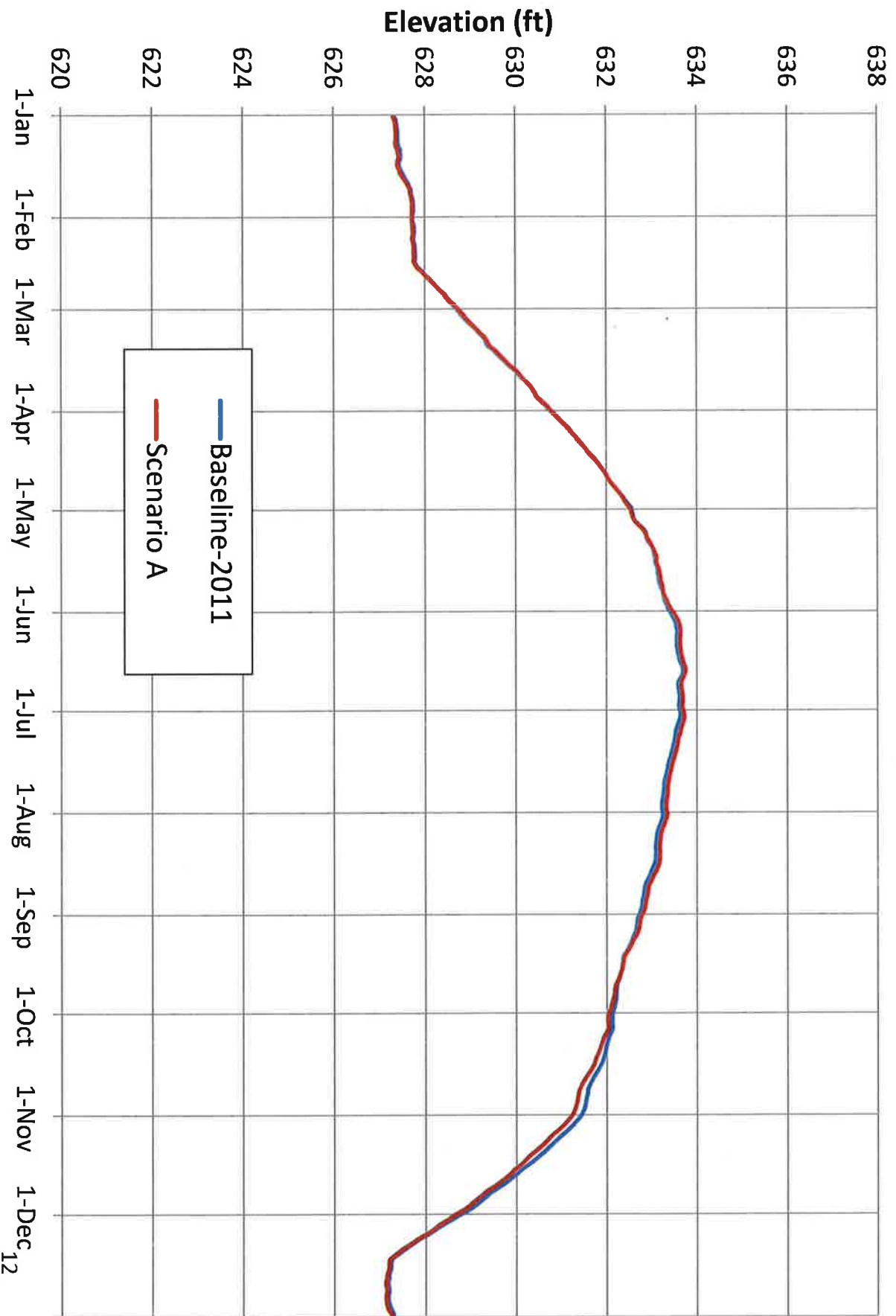
Simulated Minimum Daily Elevation at Lanier



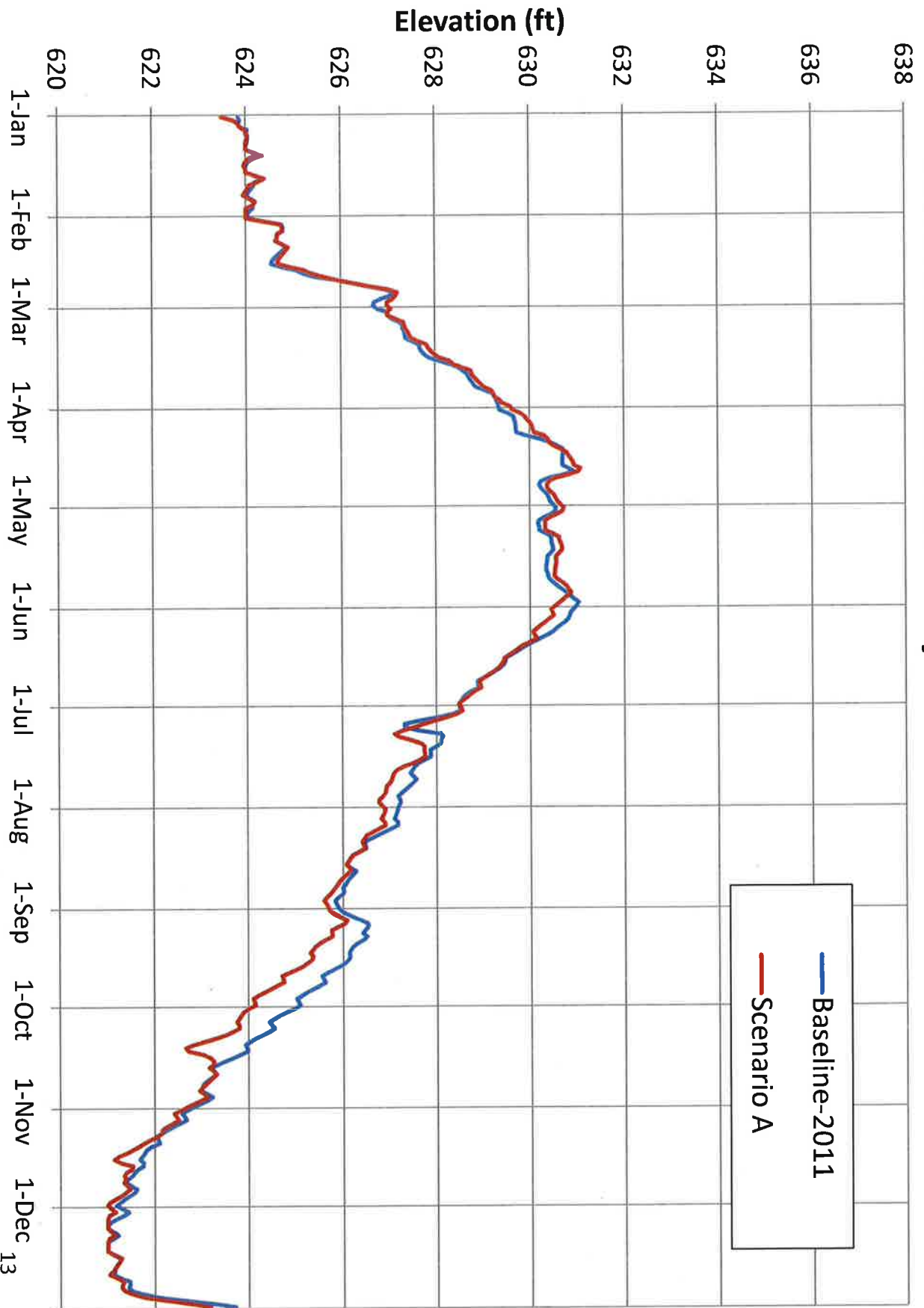
Duration Curve of Lanier Elevation



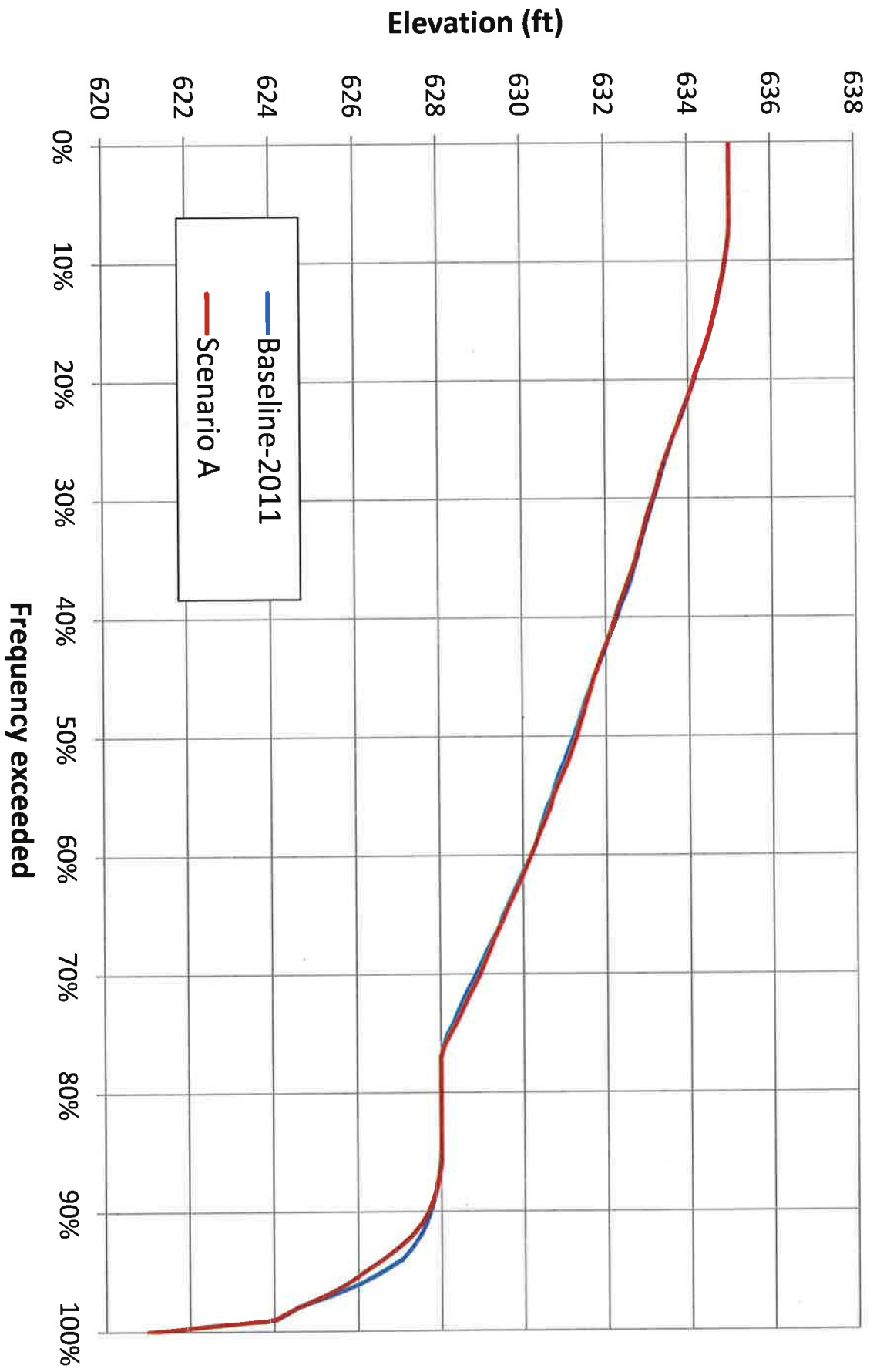
Simulated Average Daily Elevation at West Point



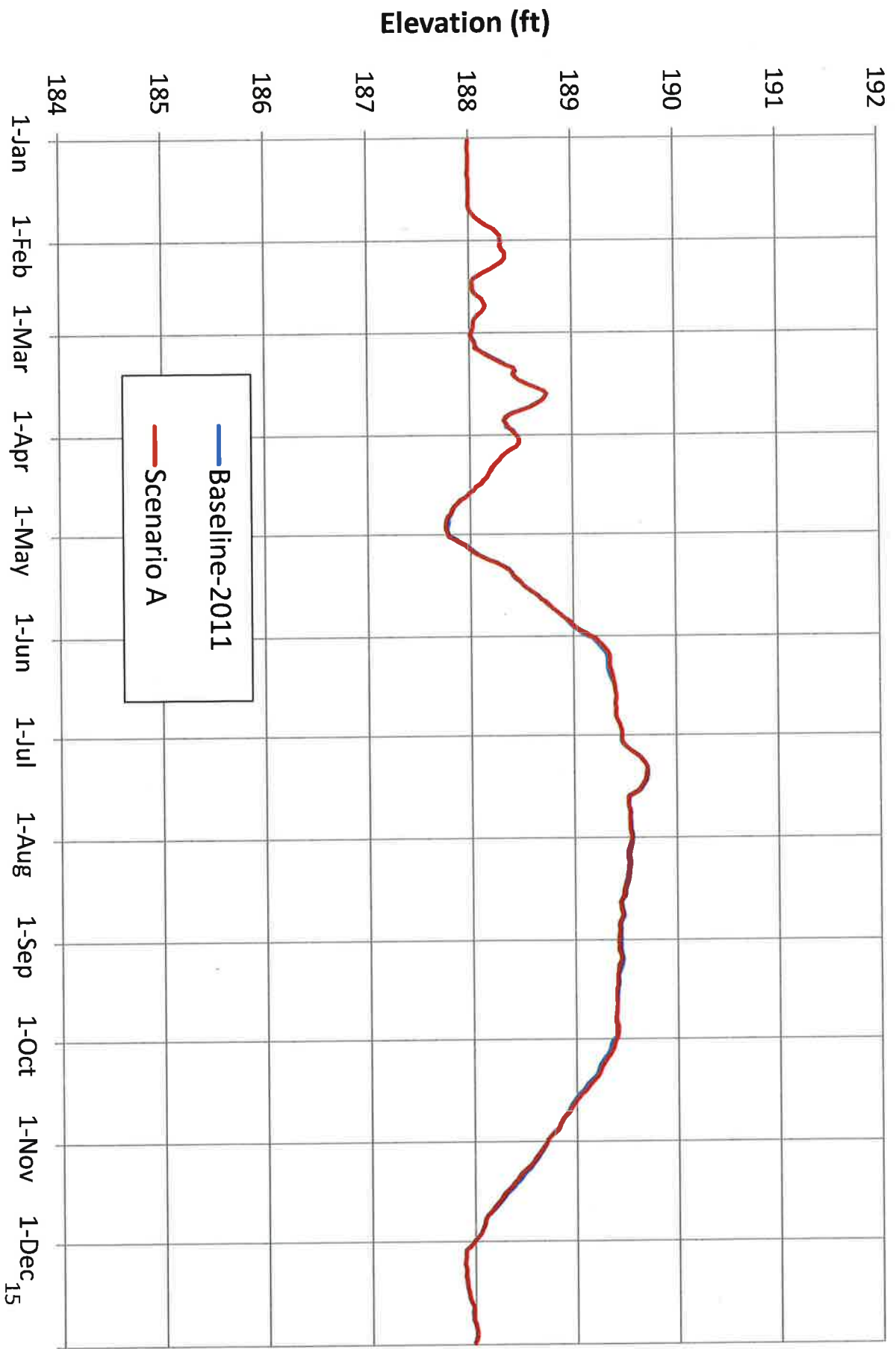
Simulated Minimum Daily Elevation at West Point



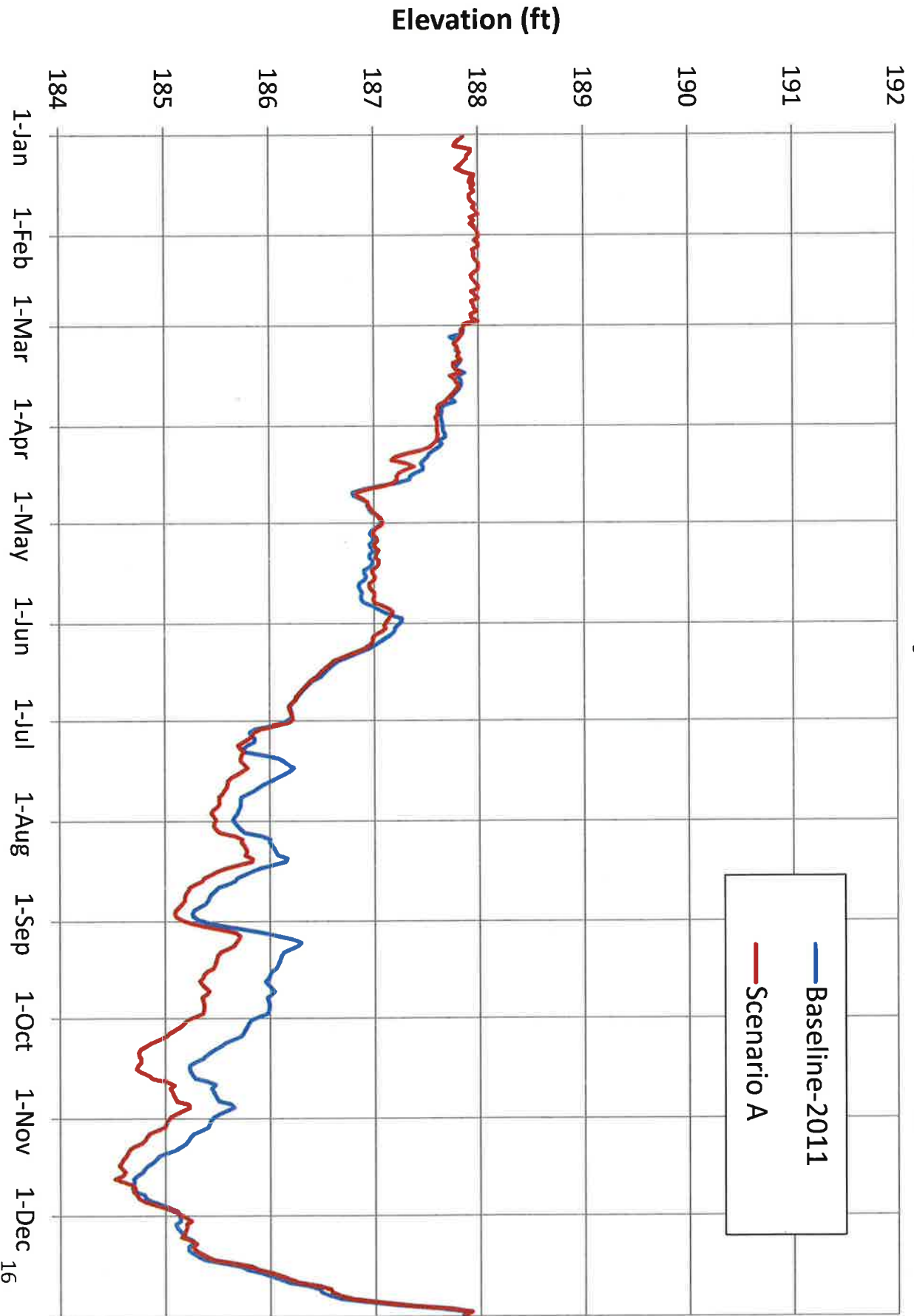
Duration Curve of West Point Elevation



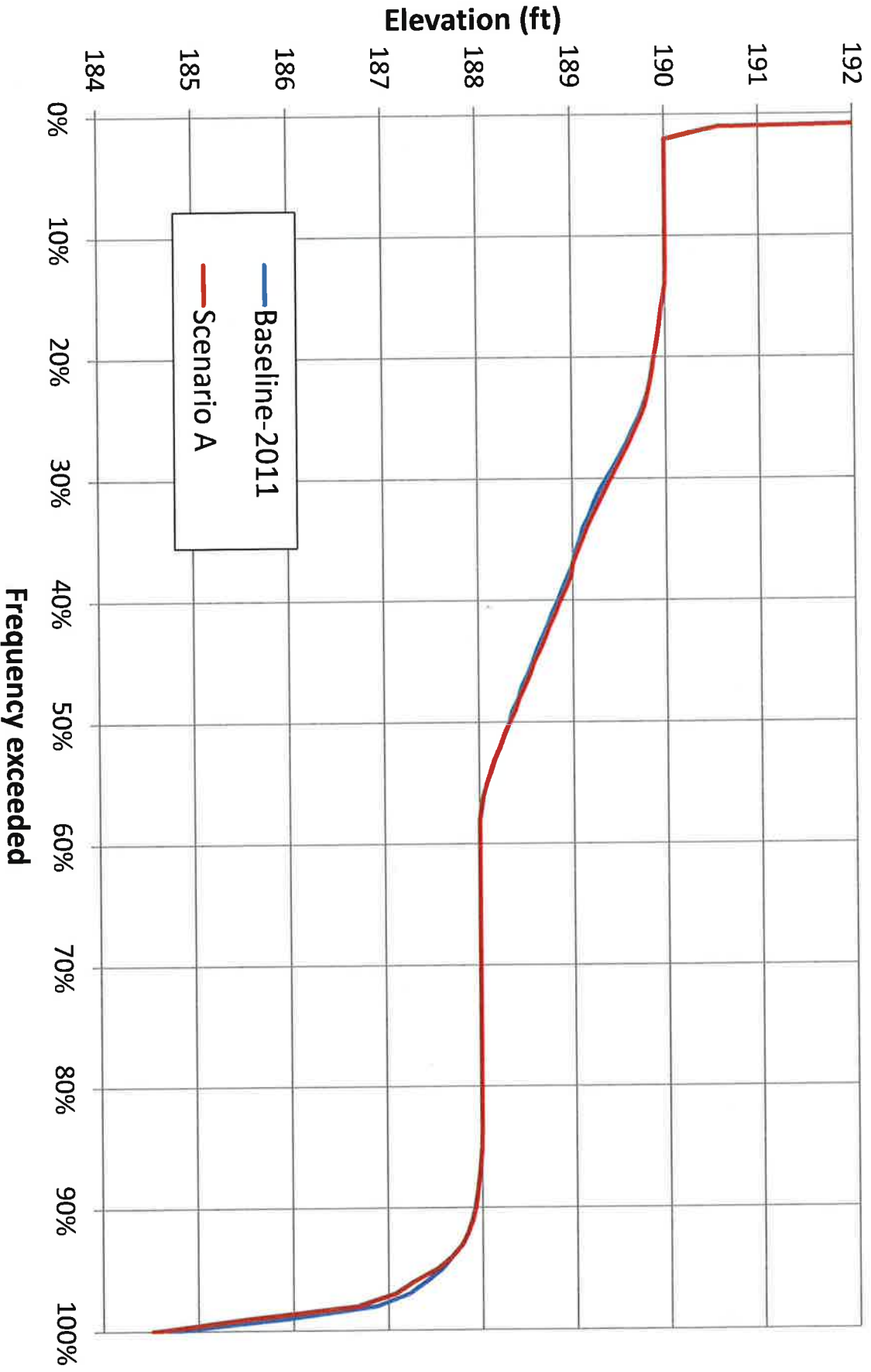
Simulated Average Daily Elevation at W. F. George



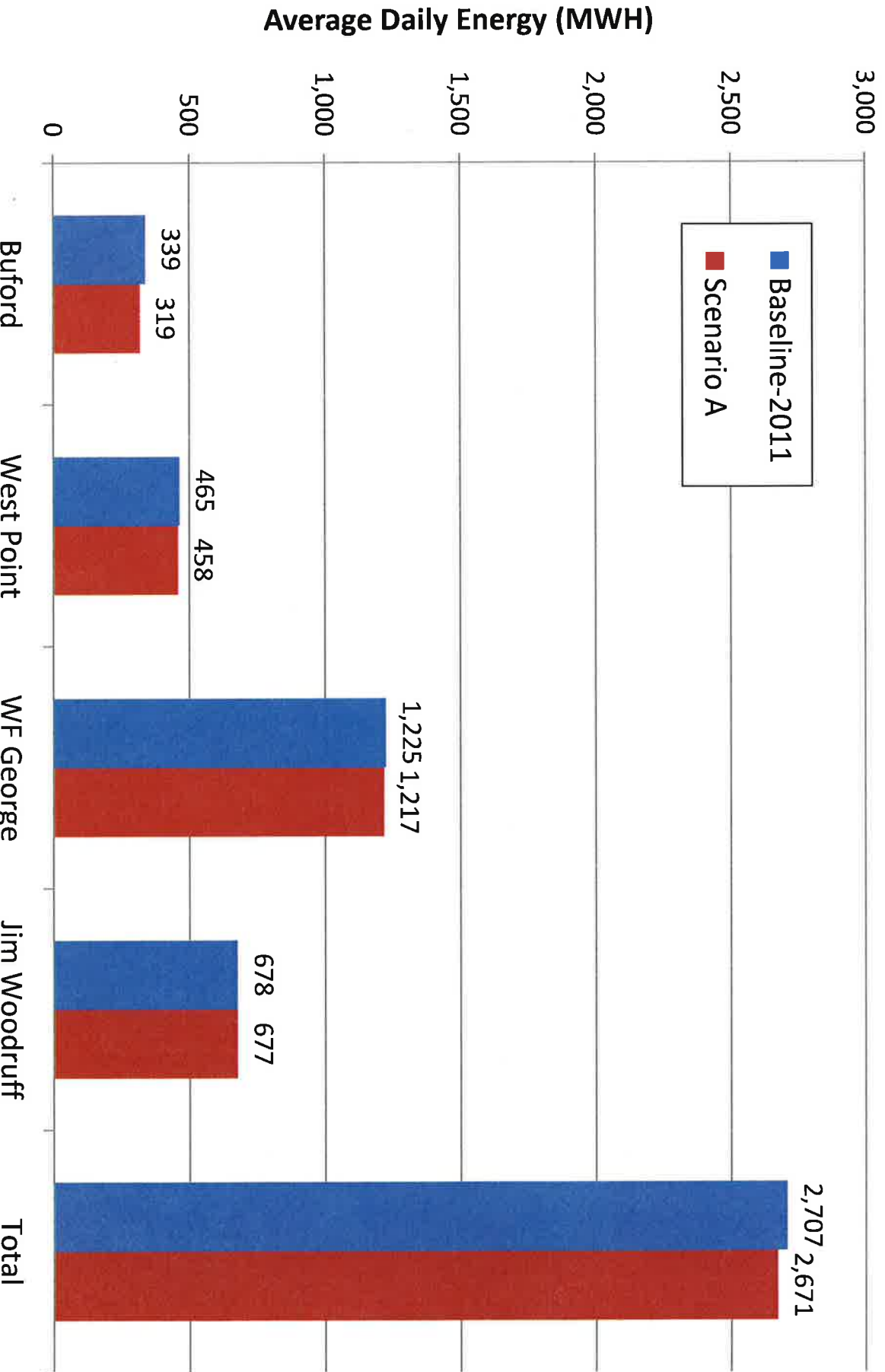
Simulated Minimum Daily Elevation at W. F. George



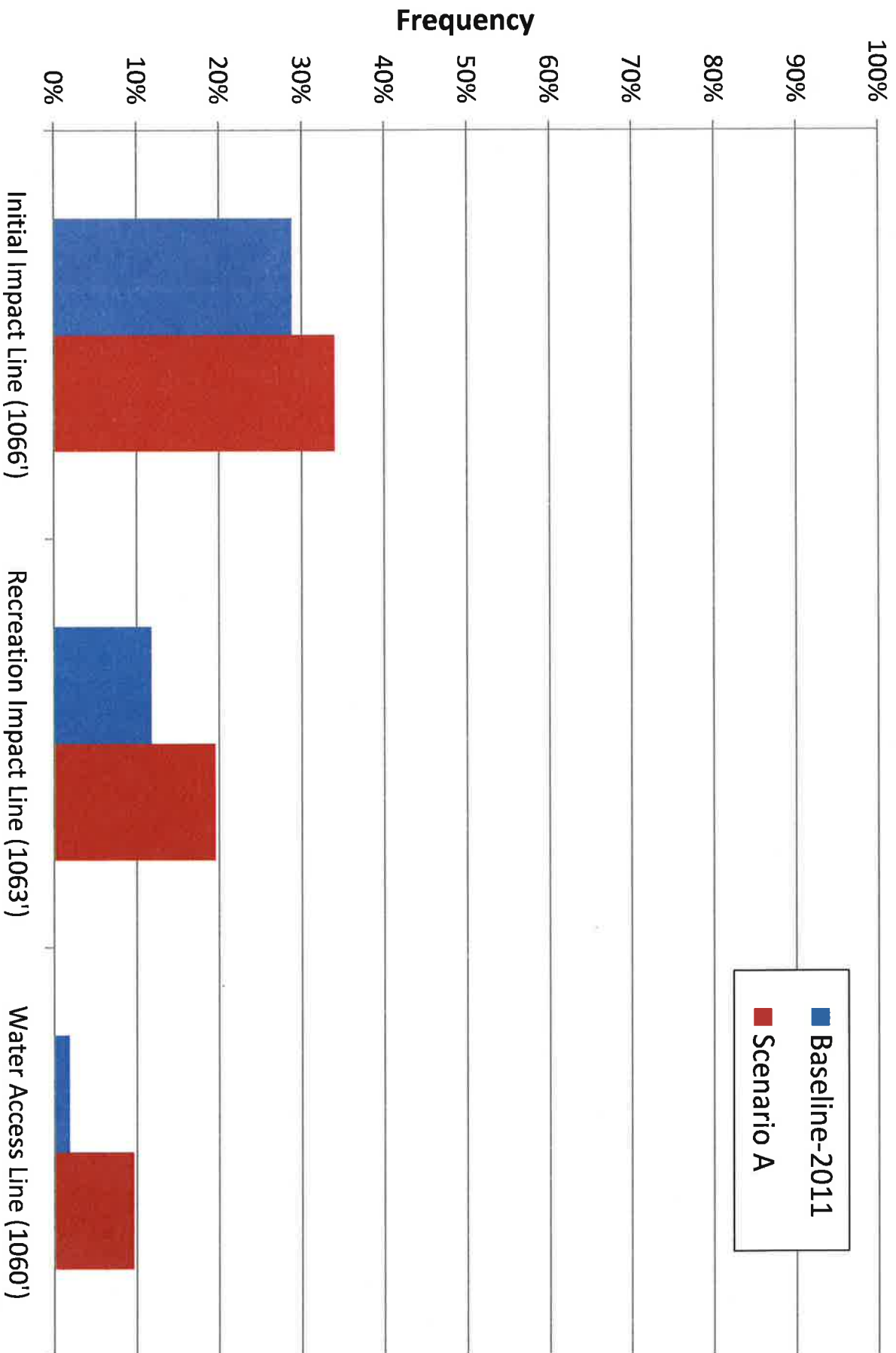
Duration Curve of W. F. George Elevation



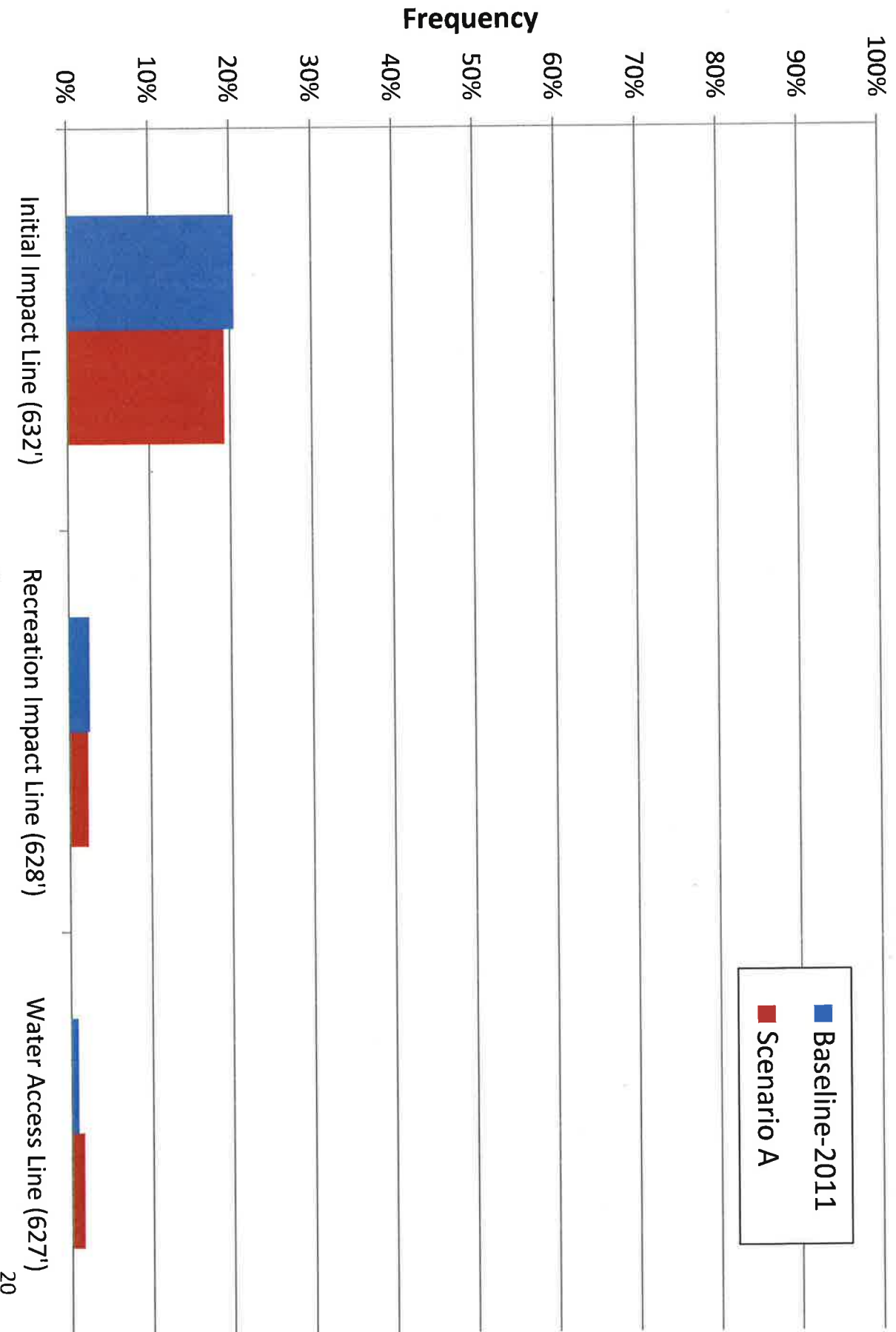
Simulated Power Generation at Federal Reservoirs in GA



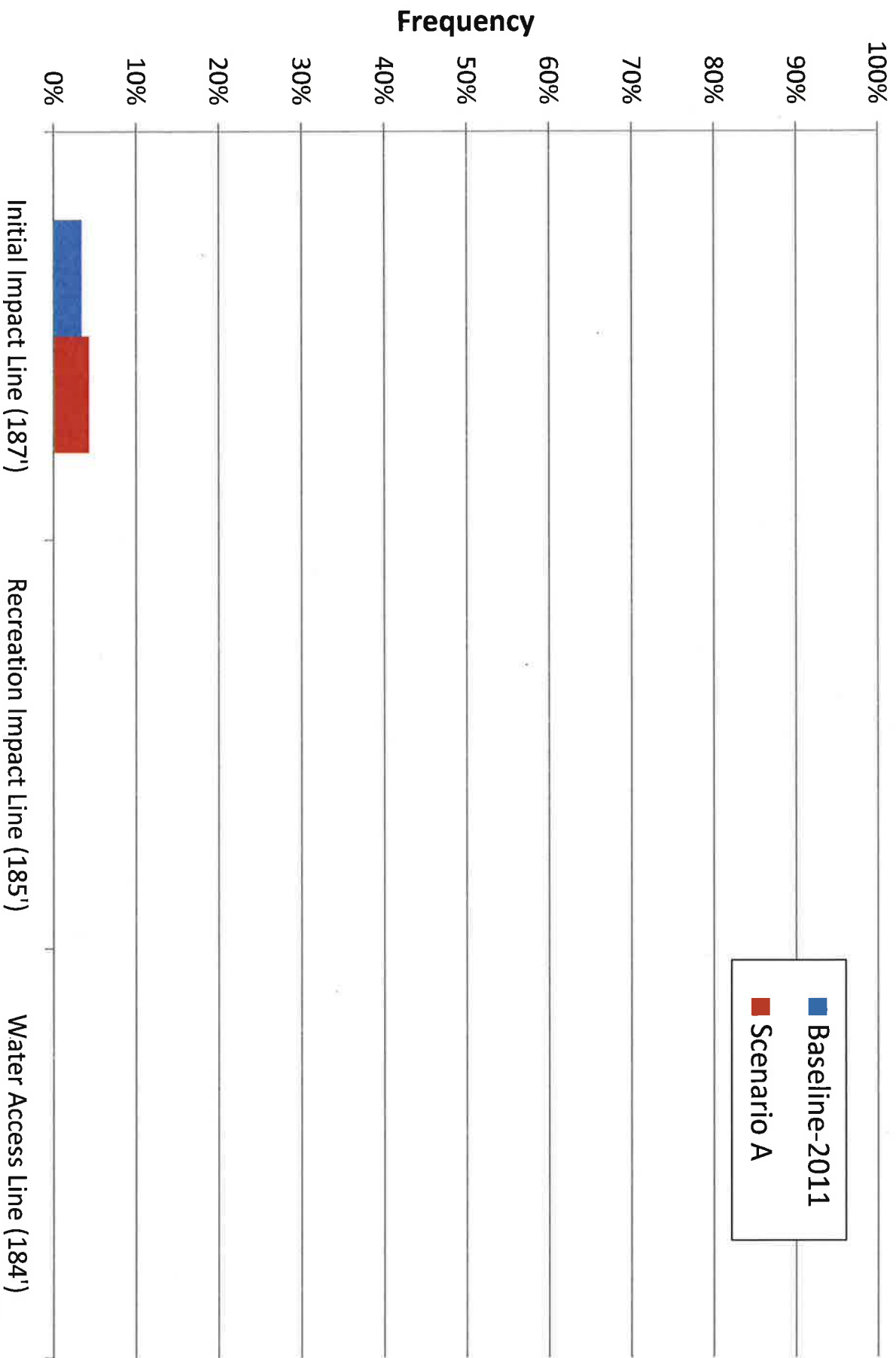
Lanier Frequency of Simulated Recreational Impacts



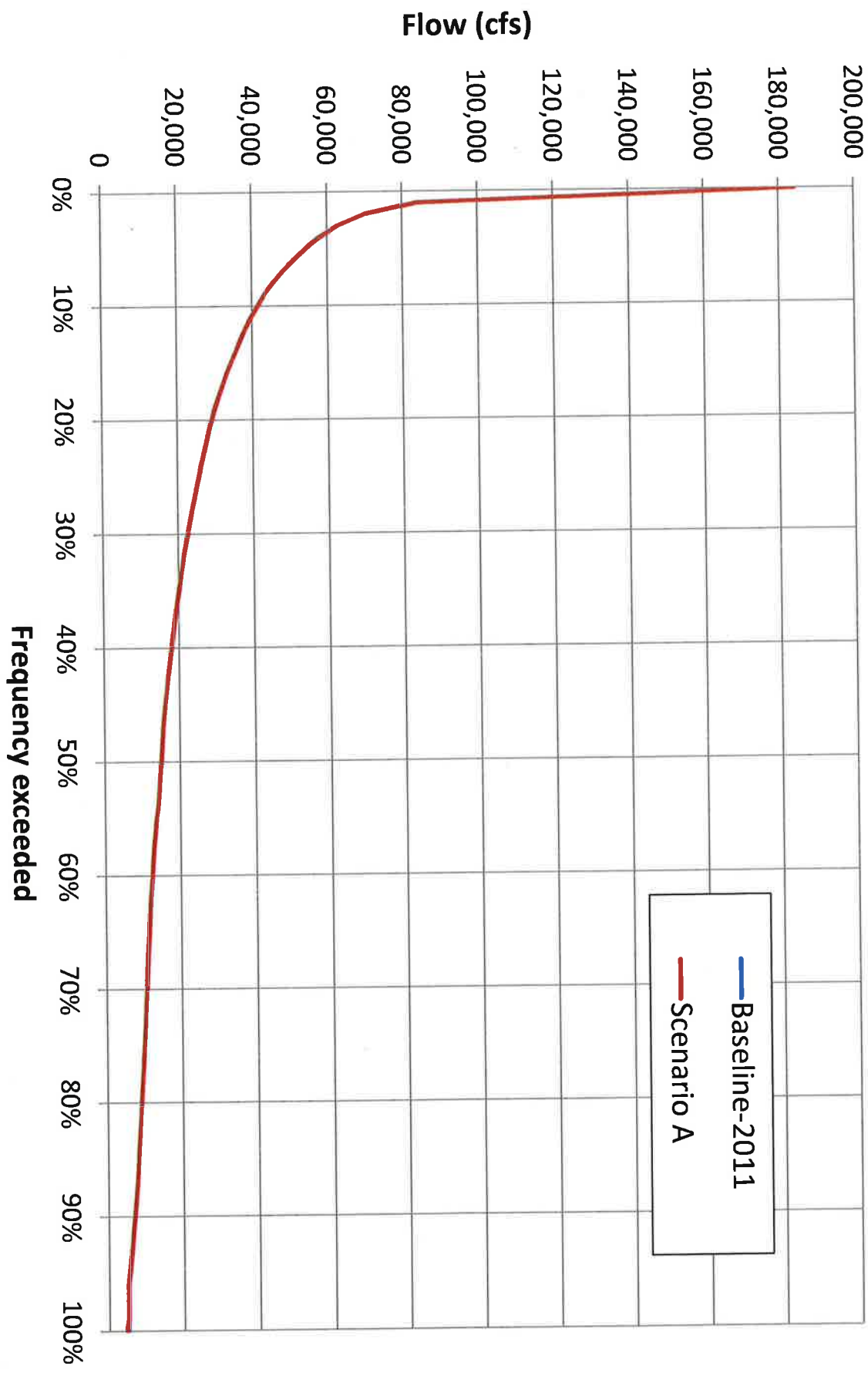
West Point Frequency of Simulated Recreational Impacts



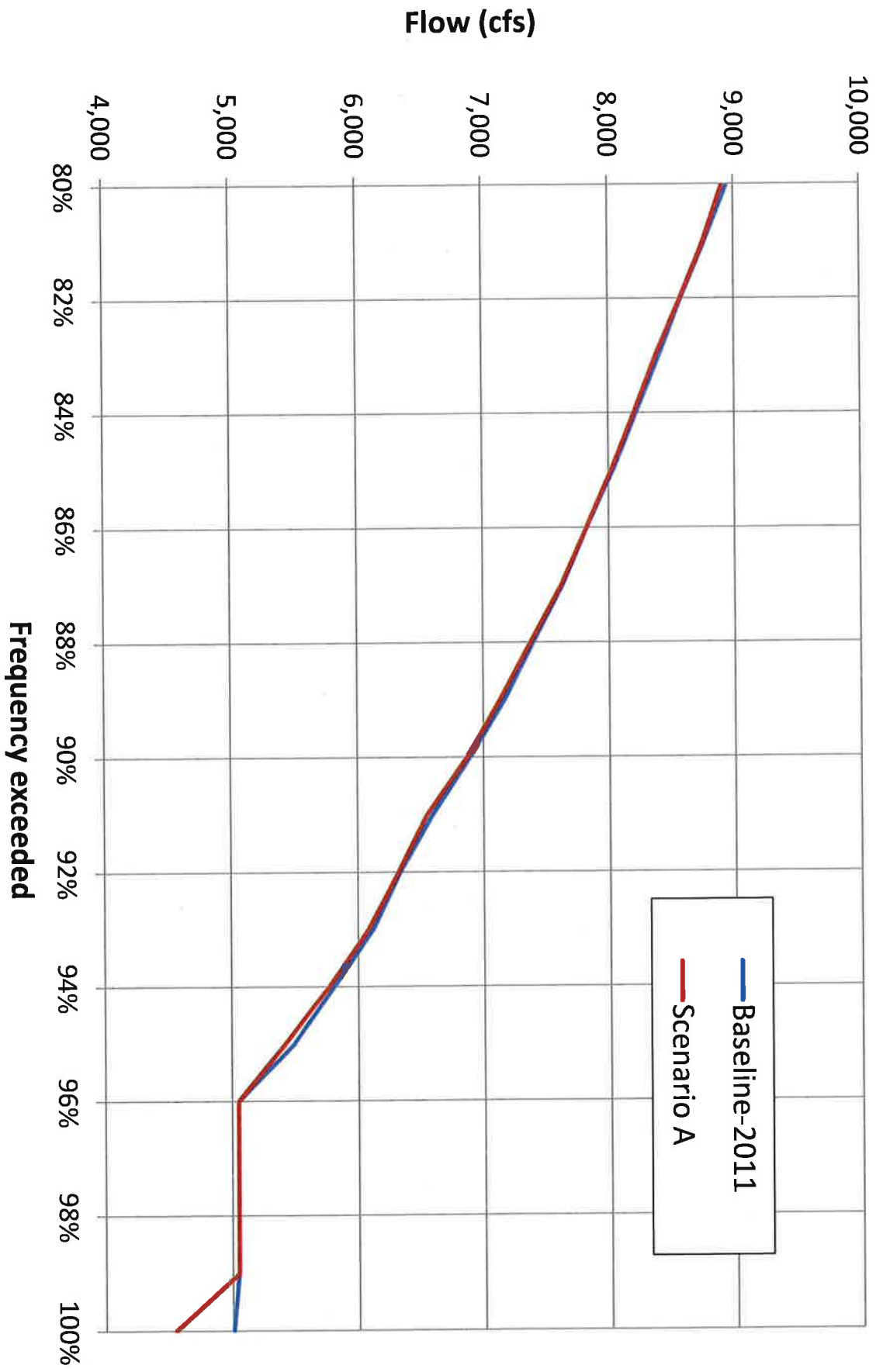
W. F. George Frequency of Simulated Recreational Impacts



Duration Curve of State Line Flow

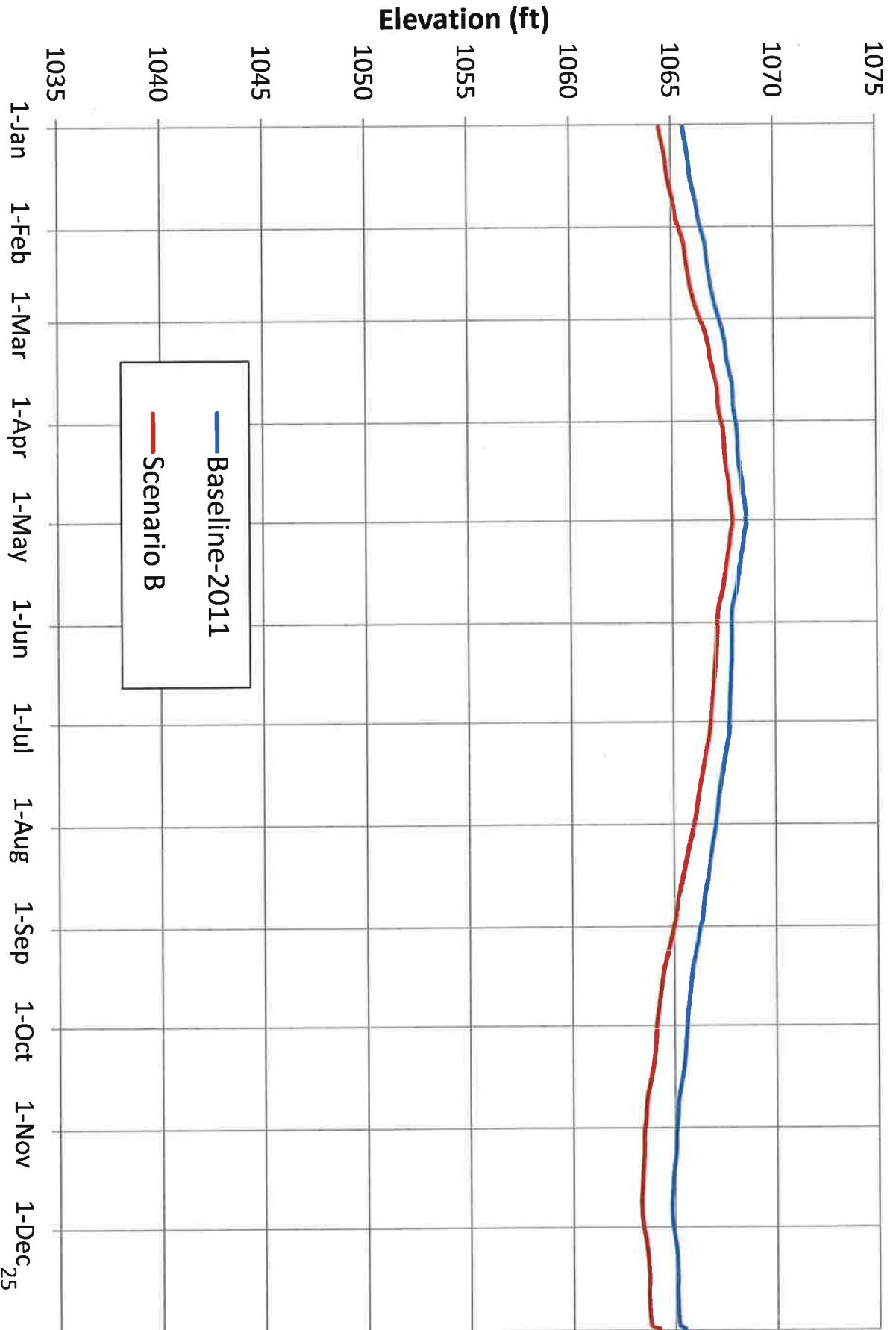


Duration Curve of State Line Flow

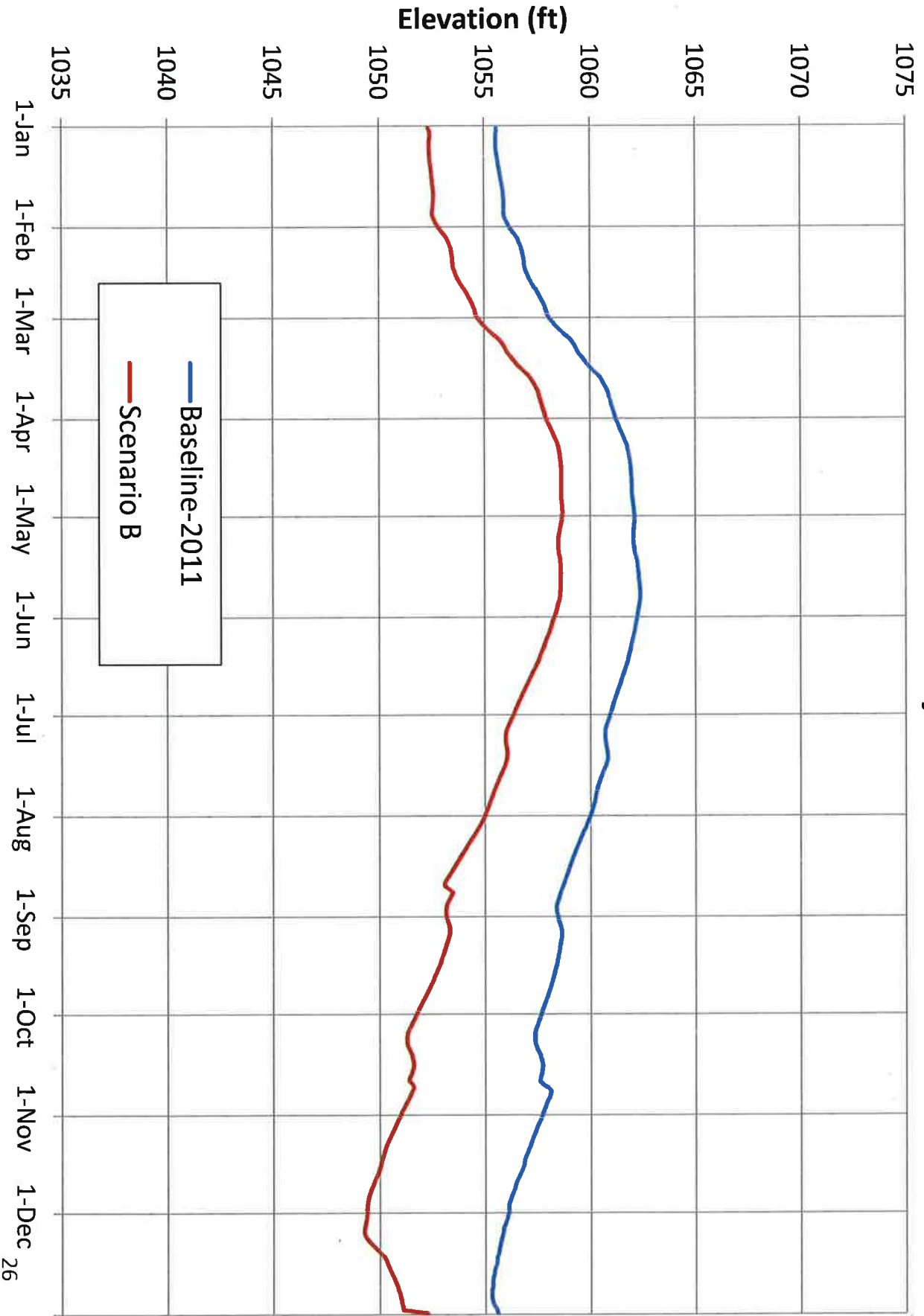


Scenario B vs. Baseline

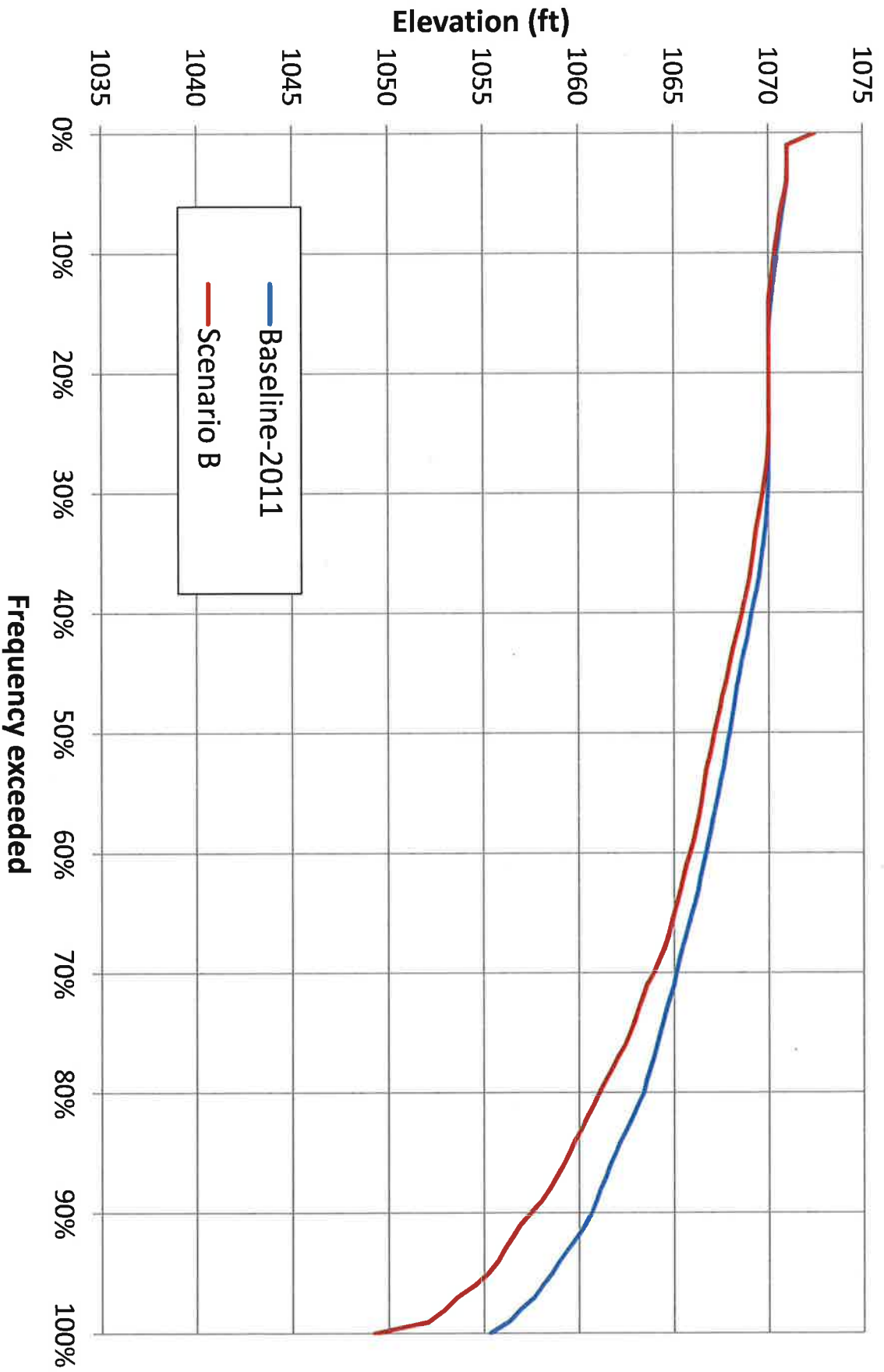
Simulated Average Daily Elevation at Lanier



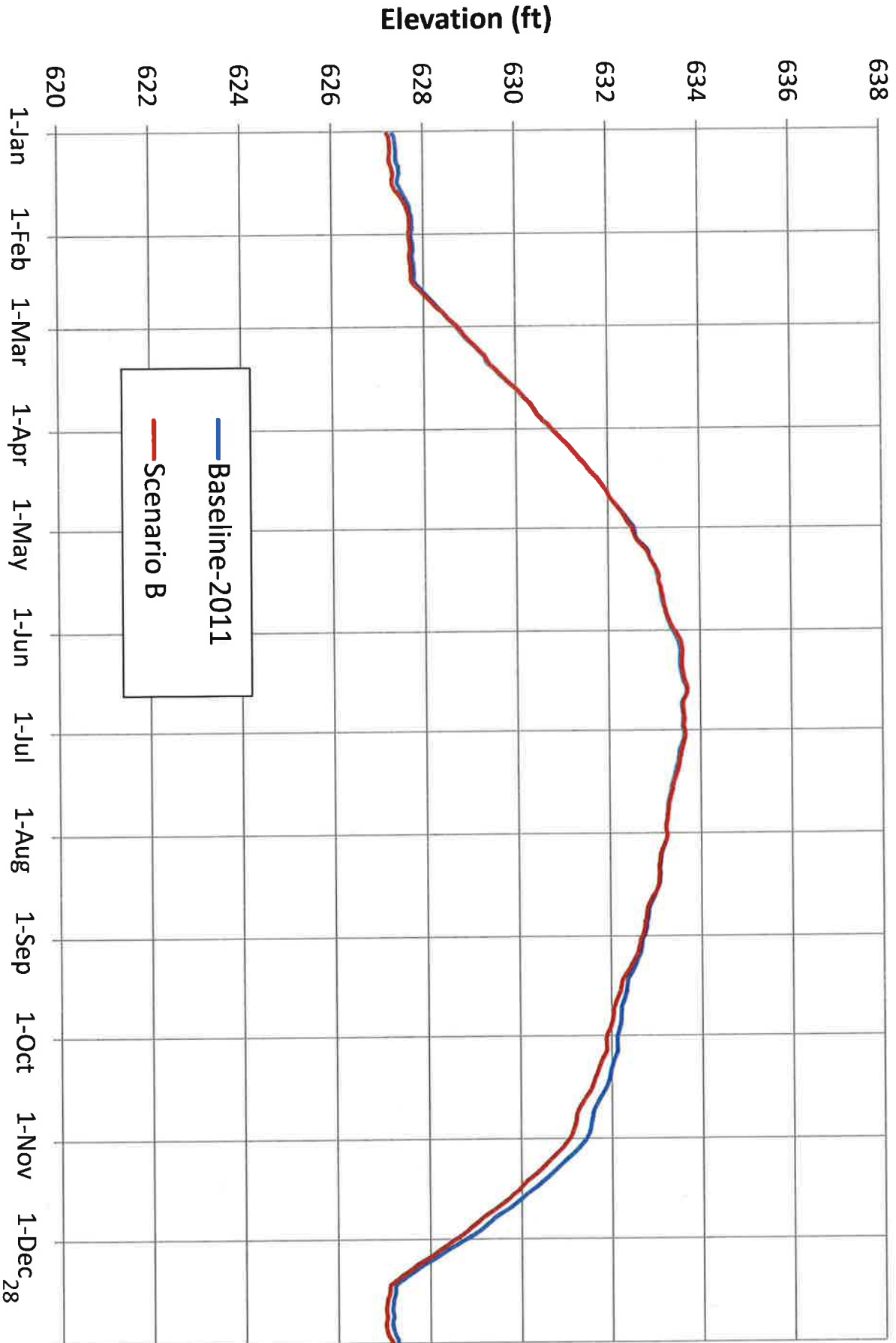
Simulated Minimum Daily Elevation at Lanier



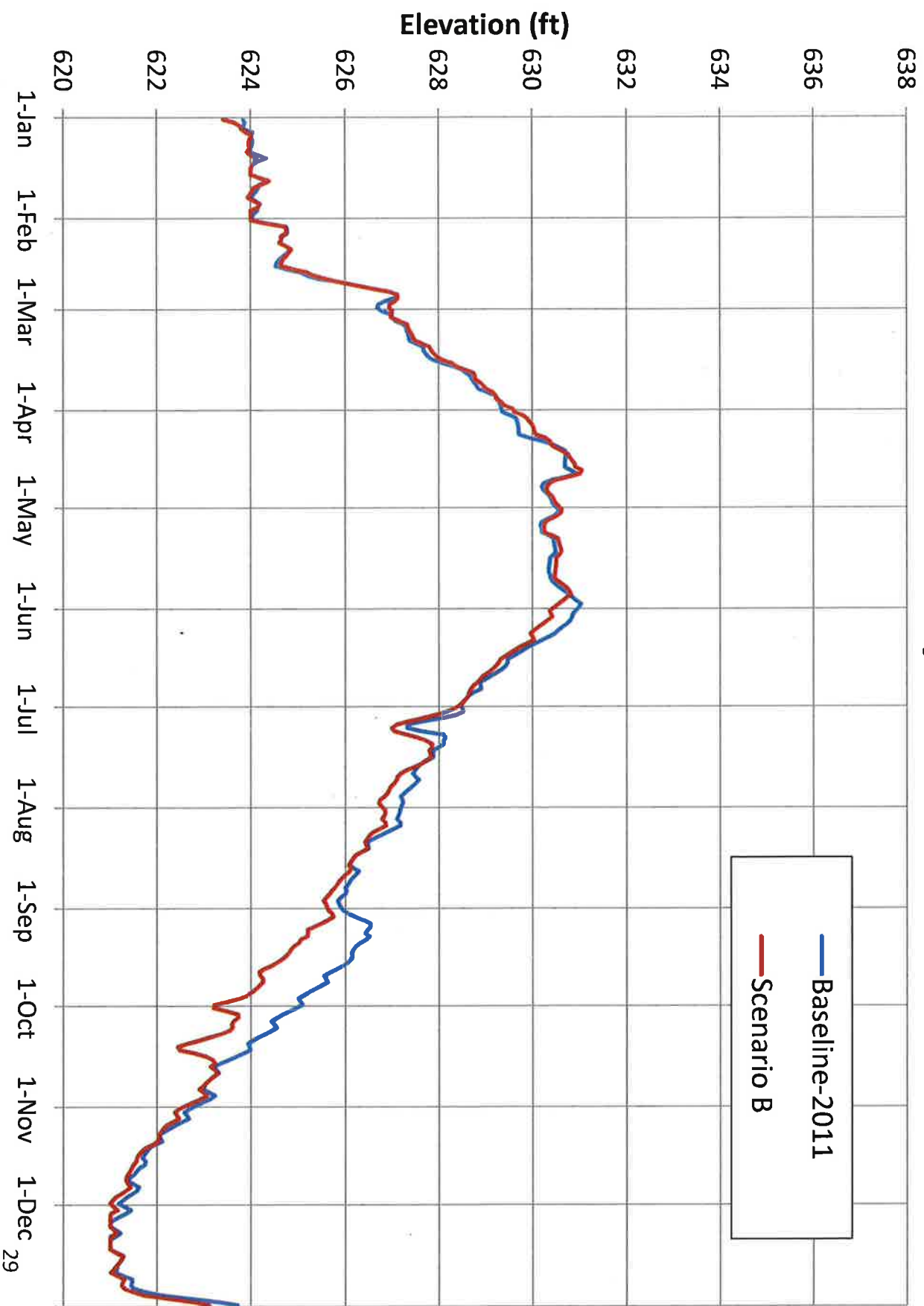
Duration Curve of Lanier Elevation



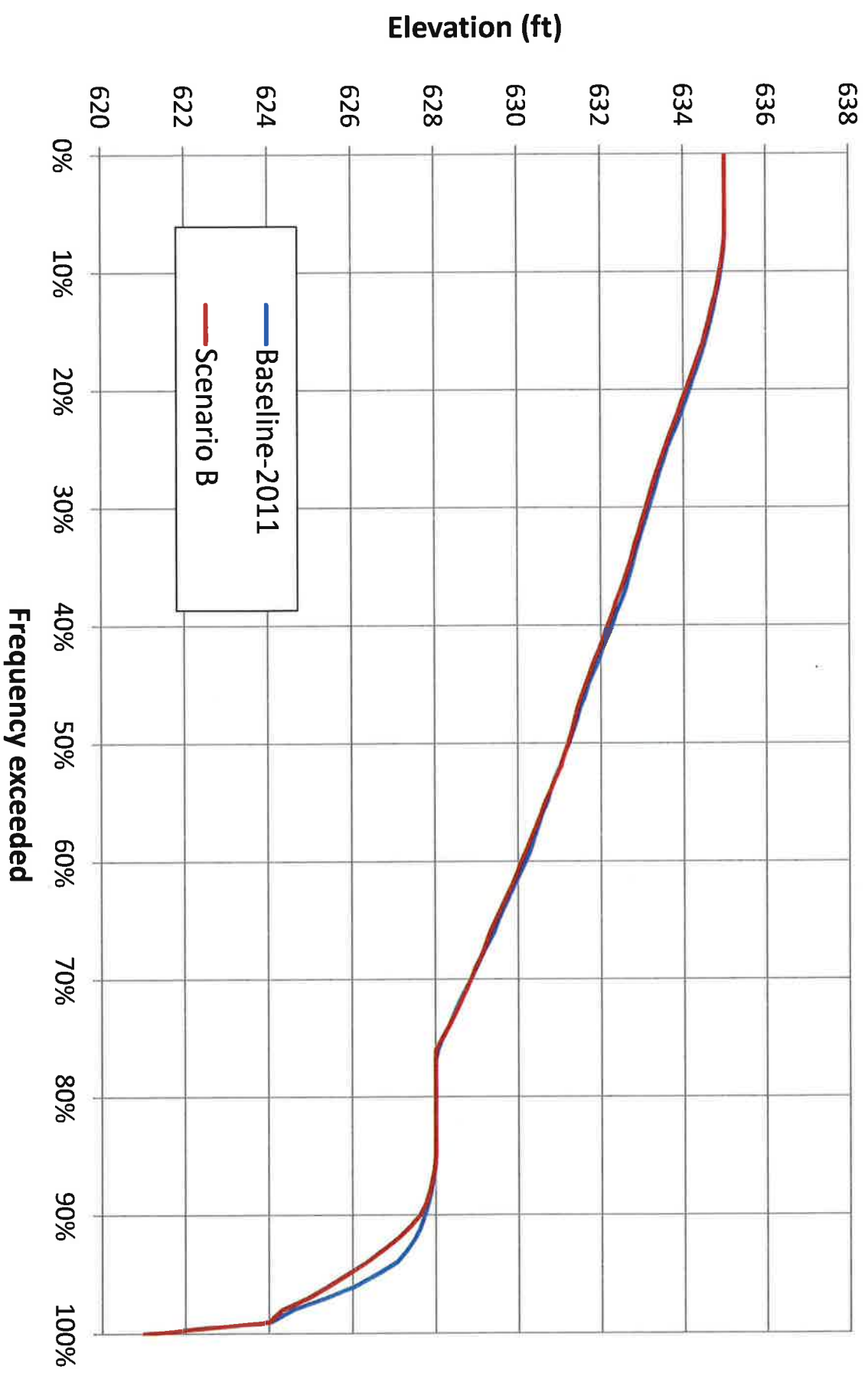
Simulated Average Daily Elevation at West Point



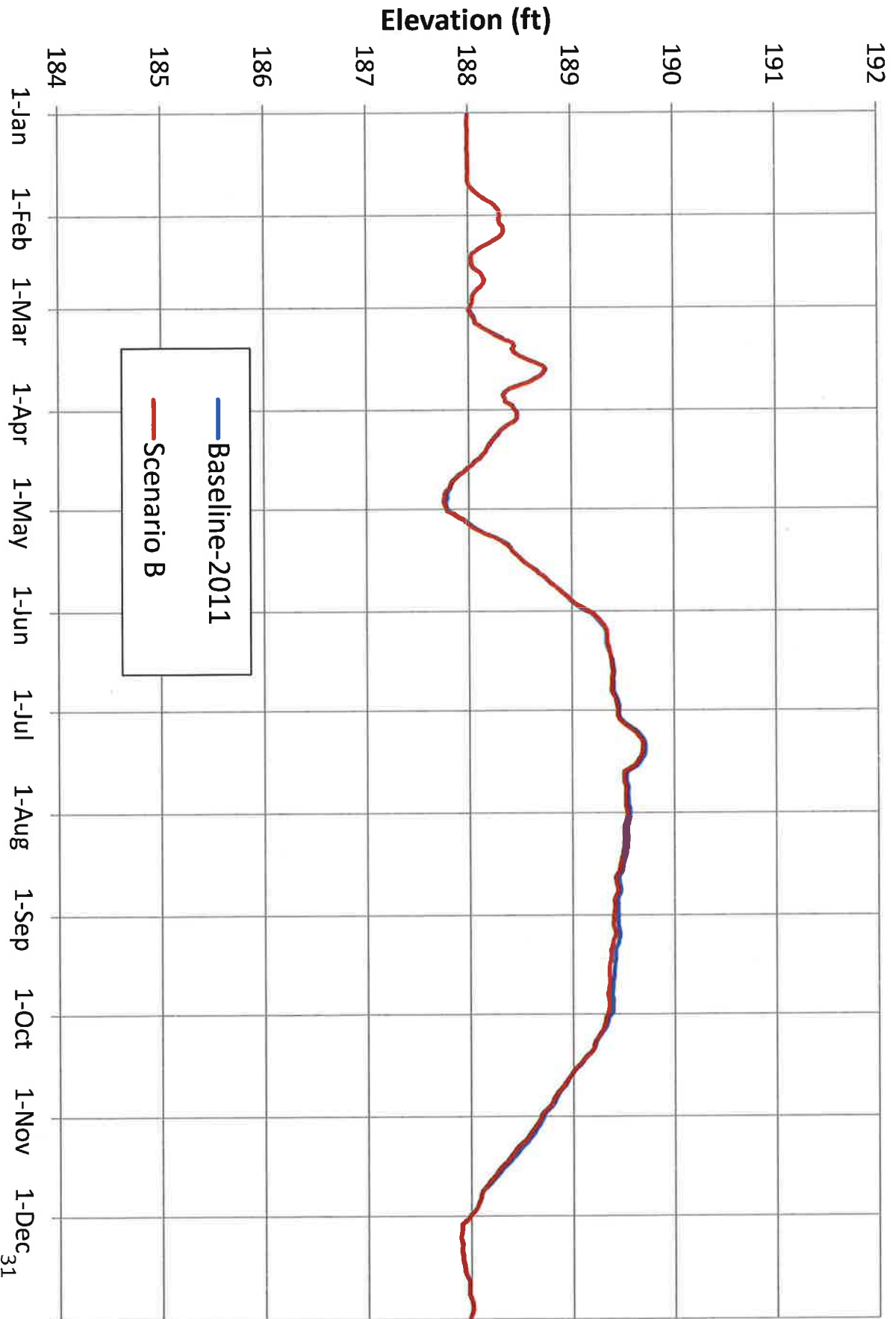
Simulated Minimum Daily Elevation at West Point



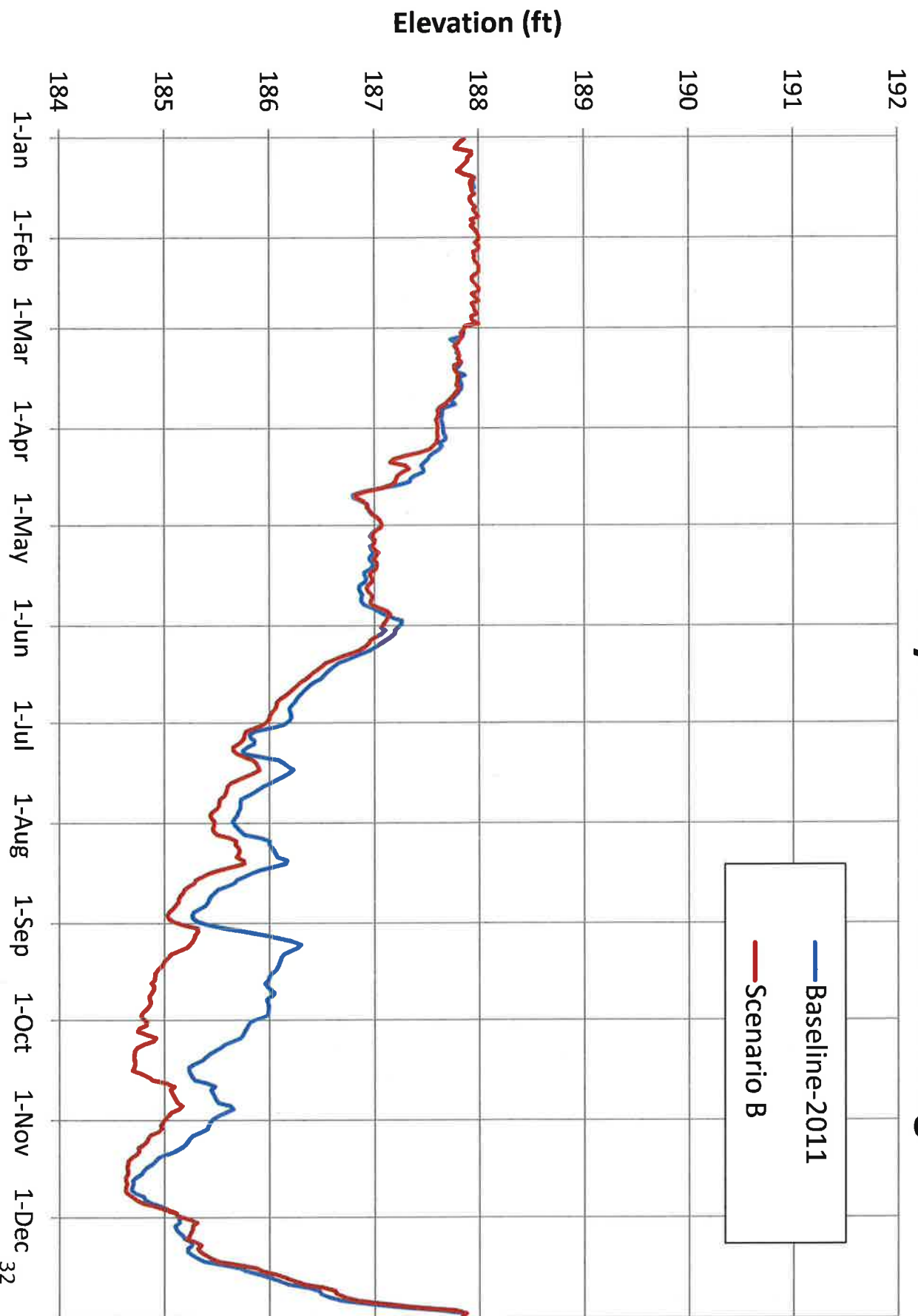
Duration Curve of West Point Elevation



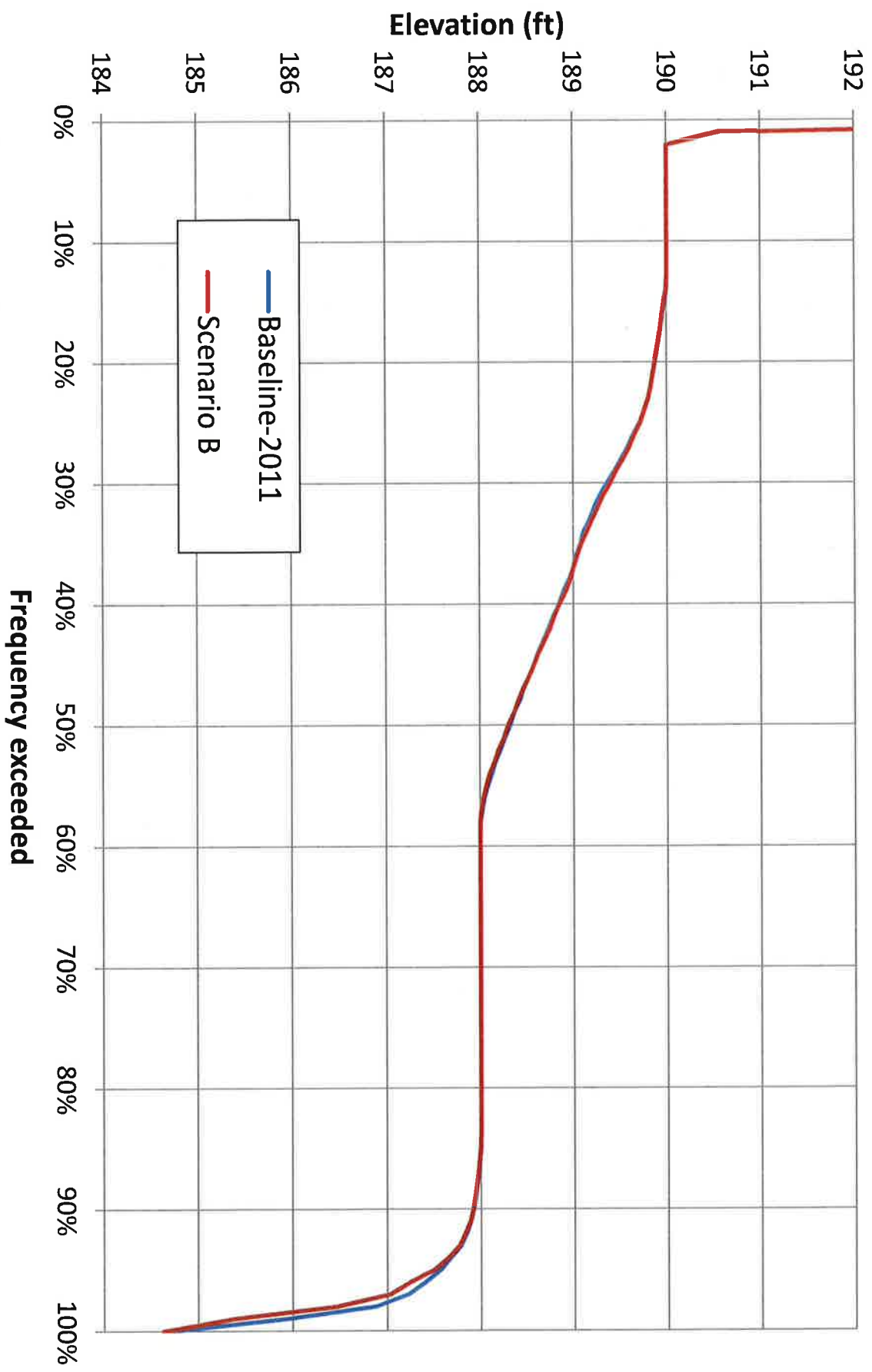
Simulated Average Daily Elevation at W. F. George



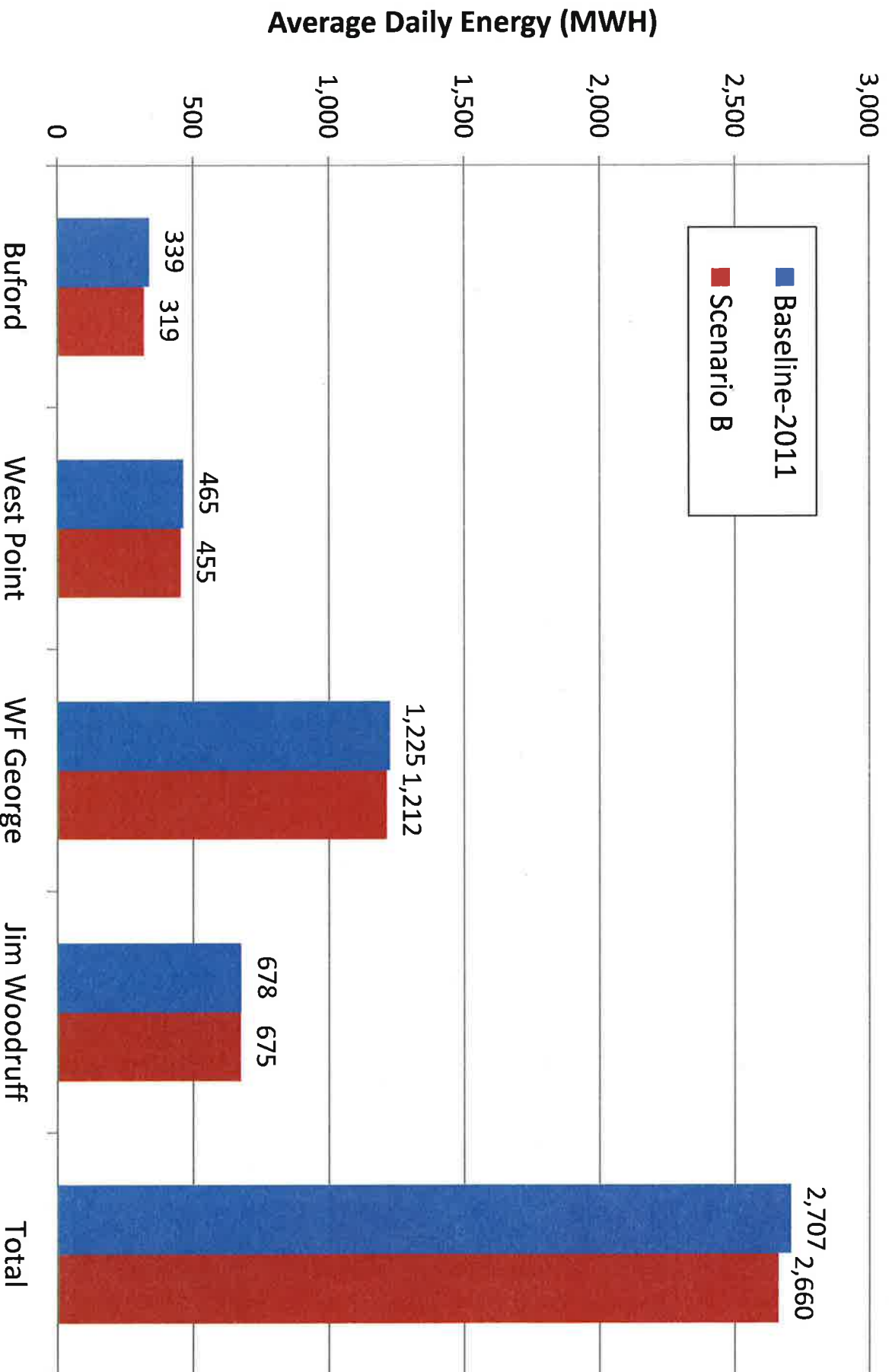
Simulated Minimum Daily Elevation at W. F. George



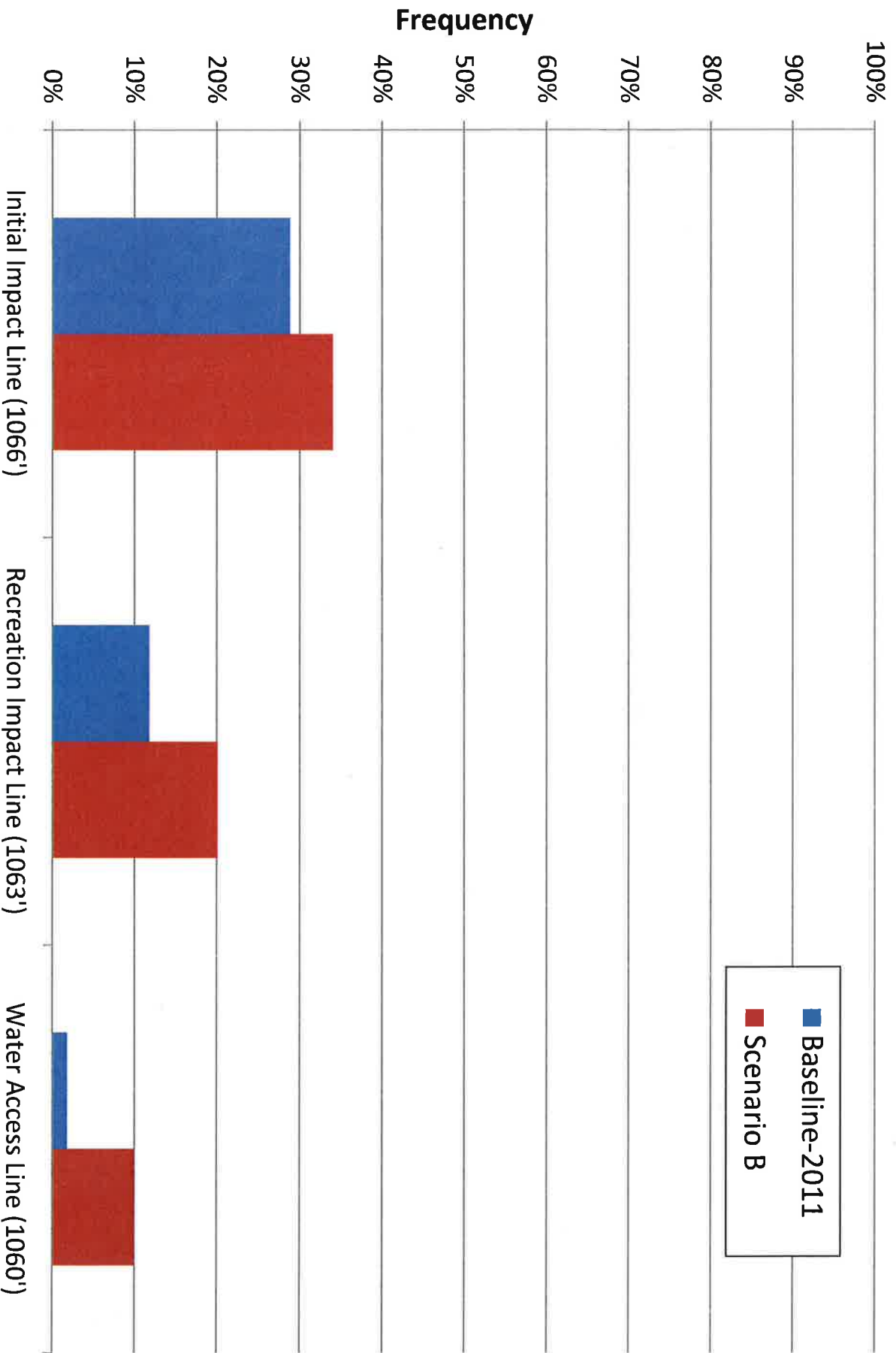
Duration Curve of W. F. George Elevation



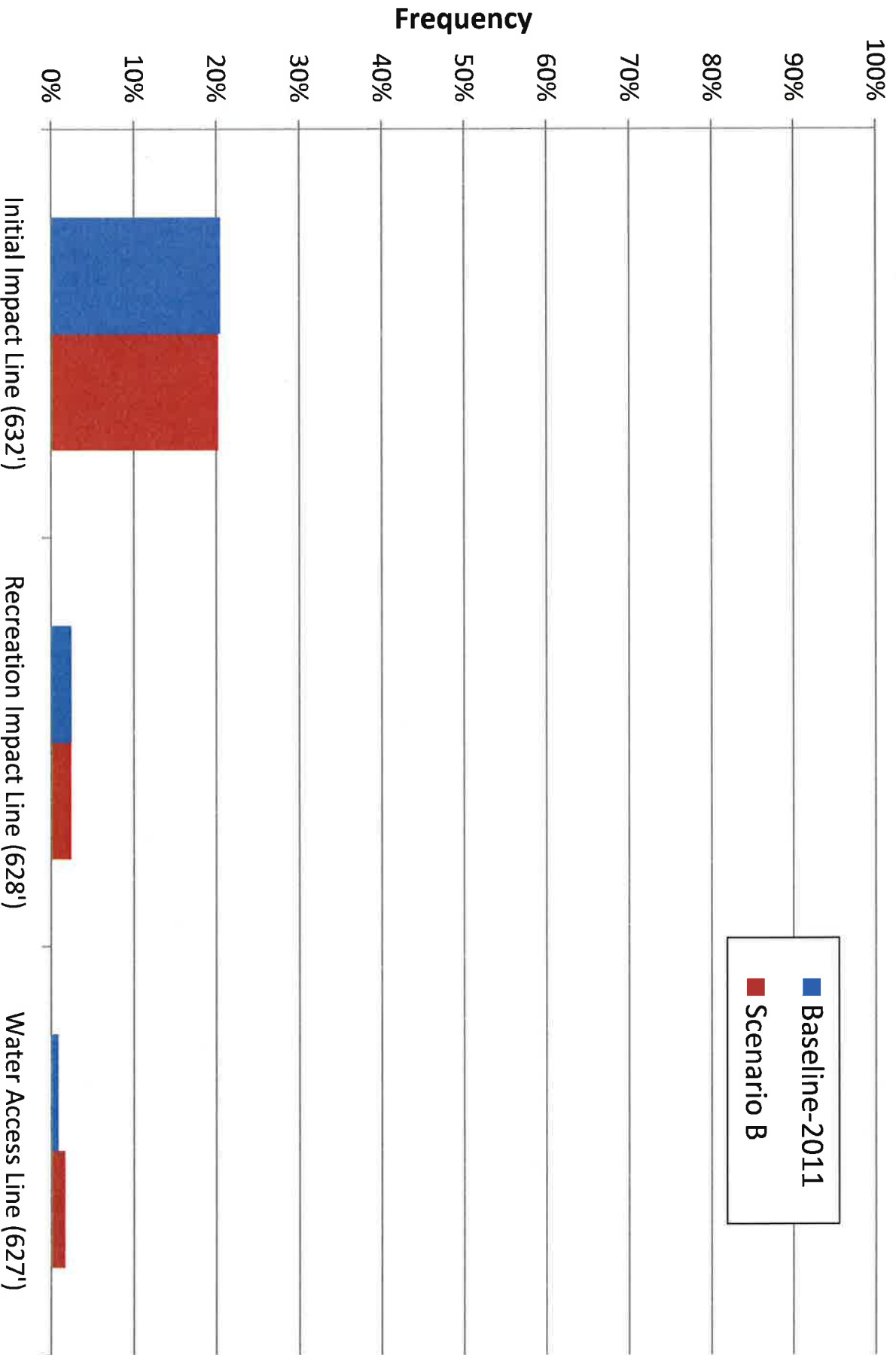
Simulated Power Generation at Federal Reservoirs in GA



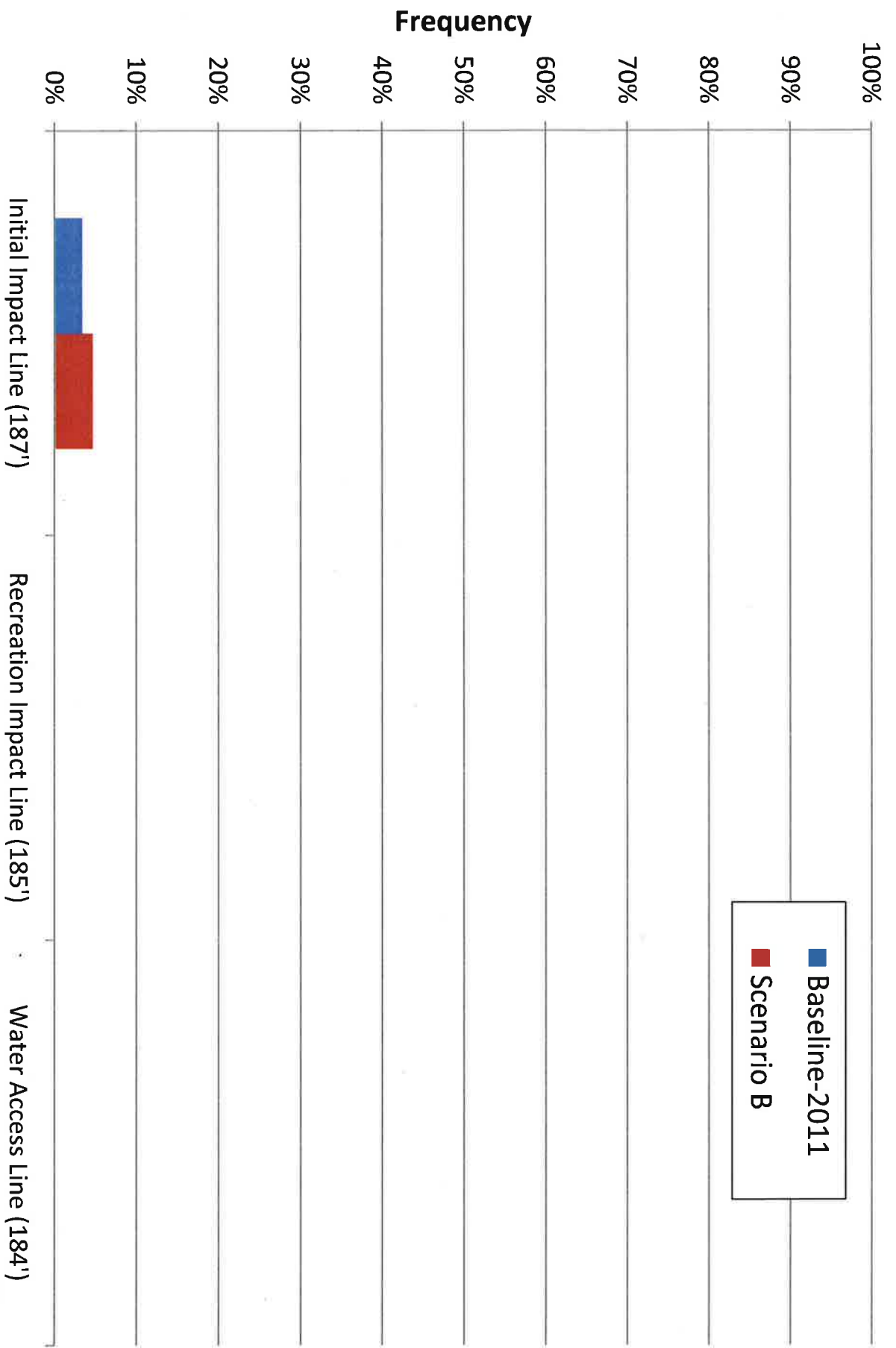
Lanier Frequency of Simulated Recreational Impacts



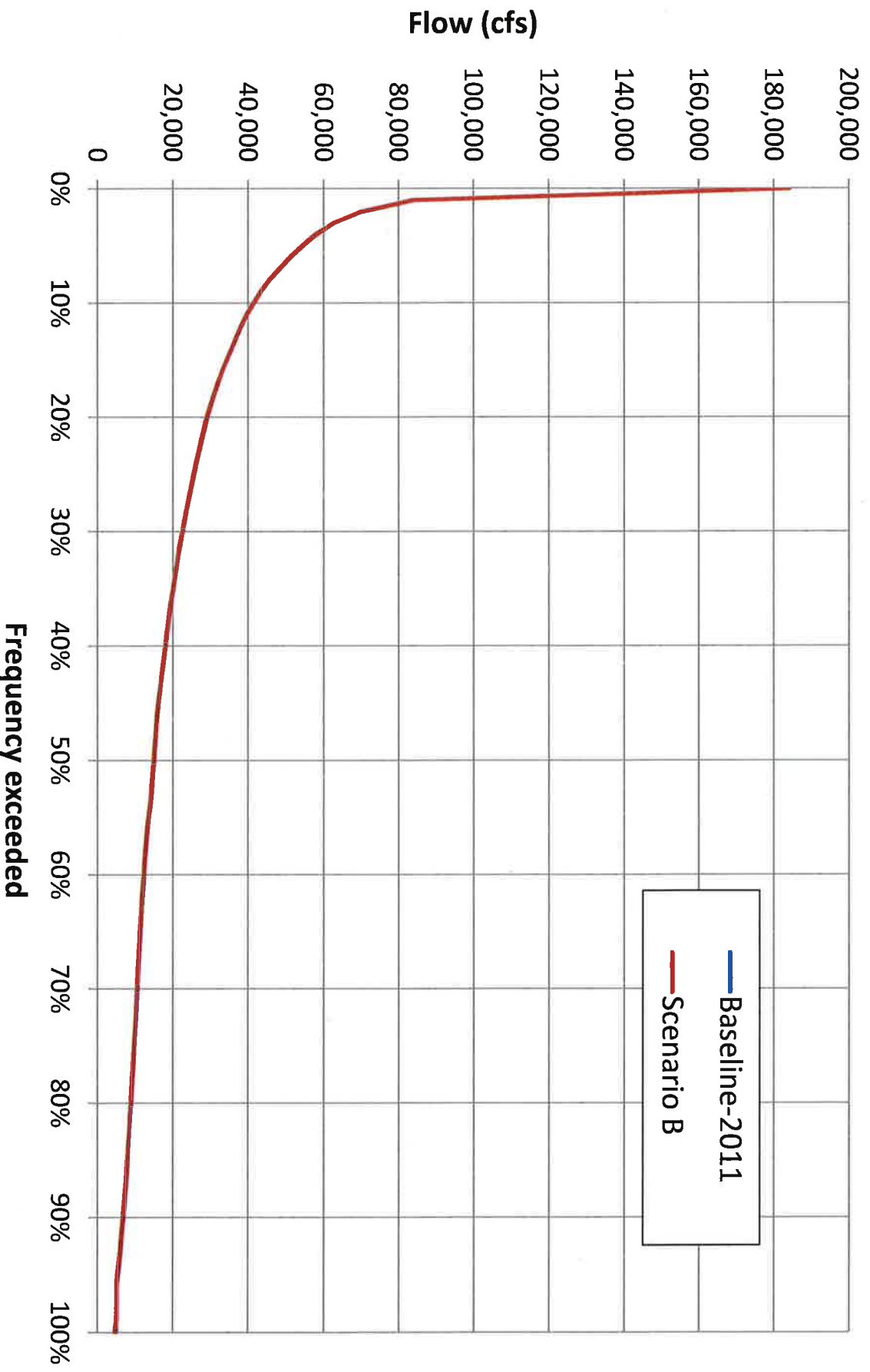
West Point Frequency of Simulated Recreational Impacts



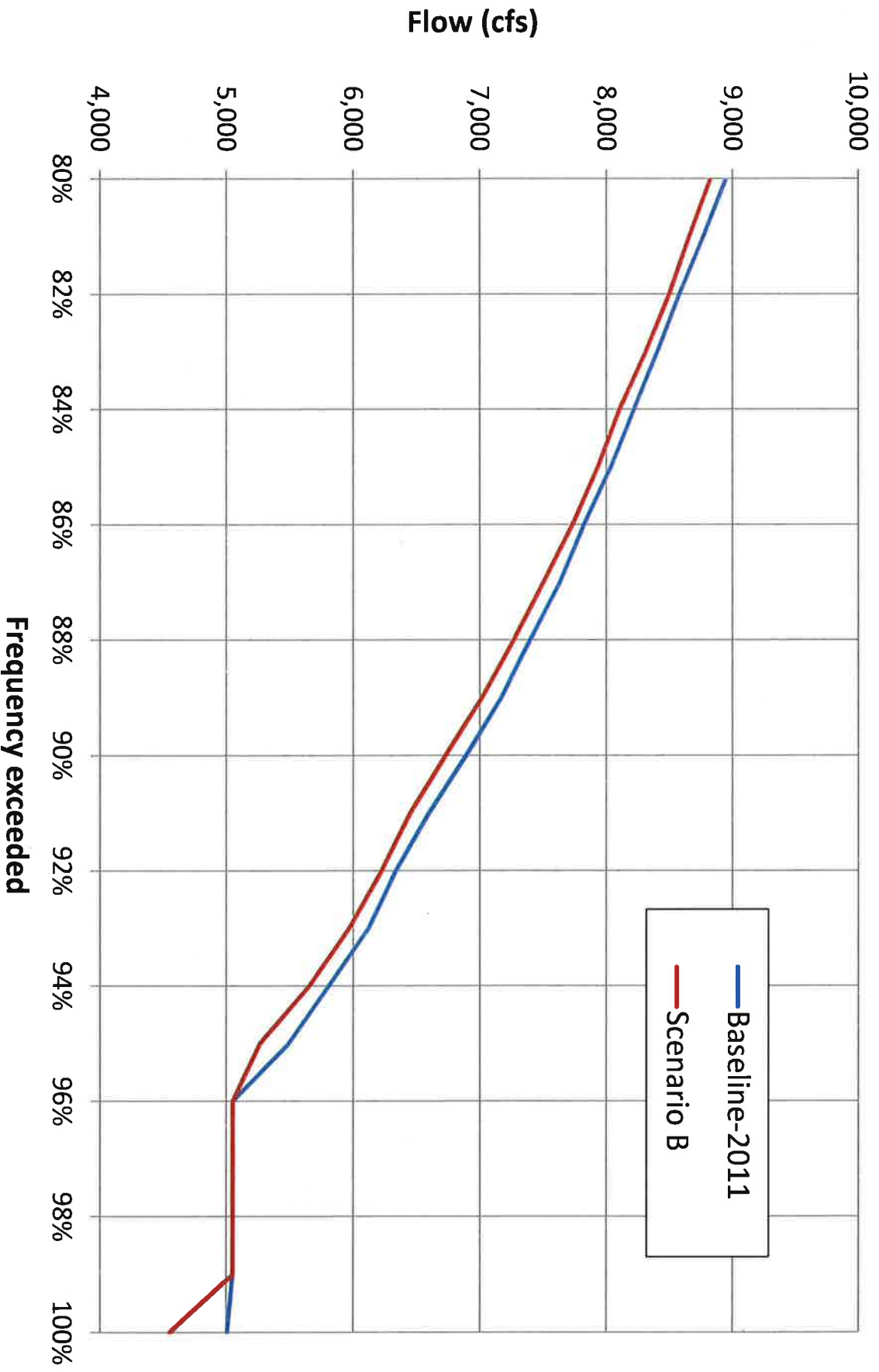
W. F. George Frequency of Simulated Recreational Impacts



Duration Curve of State Line Flow



Duration Curve of State Line Flow



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1 **Appendix B: Georgia Water Supply Alternatives – Response to U.S. Army**
2 **Corps of Engineers RFI**

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Georgia Department of Natural Resources

Environmental Protection Division

2 Martin Luther King Jr., Drive, Suite 1456 East Tower, Atlanta, Georgia 30334

Judson H. Turner, Director

(404) 656-4713

May 30, 2014

BY ELECTRONIC MAIL AND U.S. MAIL

Colonel Jon J. Chytka, Commander
U.S. Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628

Re: Corps of Engineers' Request for Additional Information for the State of Georgia's
January 11, 2013 Water Supply Request

Dear Colonel Chytka:

I am writing in response to your February 11, 2014 request that the State of Georgia provide additional information to supplement the information provided in Governor Nathan Deal's letter dated January 11, 2013, which updated Georgia's 2000 request for releases from Buford Dam to supply 408 million gallons per day (mgd) for downstream water supply users and reallocation of storage in Lake Lanier to provide for direct withdrawals of 297 mgd. Your request sought the following: (1) historical water use data for the past 10 years; (2) economic data for certain "contingency options;" and (3) operational scenarios for the proposed Glades Reservoir. The State of Georgia's responses to your request are included below.

Historical Water Use Data

Attachment A provides the historical water use data for the latest available ten years by water supplier in the requested data format. Your letter states that the Corps will use this information "to examine water demand elasticity for the communities/counties that currently use Lake Lanier or are anticipated to become future users." Although Georgia is supplying the data as requested, please note that there are additional factors that might affect your analysis.

Specifically, the Metropolitan North Georgia Water Planning District's (Metro Water District) Water Supply and Water Conservation Management Plan includes strategies and recommendations for water supply management and includes twelve measures for local governments to adopt. One such measure is that conservation pricing be used by all Metro Water District drinking water supply utilities. All Metro Water District water utilities have implemented at least a three-tiered rate structure. Thus, demand reduction benefits from using price elasticity to moderate demand have been largely realized. If you require additional information in this regard, please do not hesitate to let us know.

Economic Data for Water Supply Options

Your February 11, 2014 letter requests that Georgia provide detailed economic information regarding certain “contingency options” found in the 2009 Water Task Force Report that the State would likely consider in “the event that Lake Lanier were unavailable for certain withdrawals.” In addition, it is our understanding the Corps has asked that the Atlanta Regional Commission provide location and sizing information for certain water supply projects that are currently in the permitting process.

In our view, neither form of inquiry would yield the most appropriate framework for the economic evaluation of alternatives to the State’s water supply request.

First, it would not be appropriate for the Corps to consider as water supply alternatives any of the specific projects discussed in the 2009 Water Task Force Report. As discussed below, Georgia has re-examined the types of water resource projects that would be needed to provide water supply to those jurisdictions that currently or in the future are projected to withdraw water directly from Lake Lanier. Based upon that analysis, Georgia has more directly responsive and accurate information than what is contained in the 2009 Water Task Force Report. Under present circumstances the State would not necessarily endorse any of the projects listed in the 2009 Report. Therefore, it is not reasonable for Georgia to speculate as to which specific project it “would likely implement” to meet future water supply needs in the unlikely event the Corps denies Georgia’s water supply request.

Second, it would also be inappropriate for the Corps to include as water supply alternatives projects that are already in the permitting process. These projects are currently scheduled to be constructed regardless of whether the Corps grants Georgia’s water supply request. These projects are necessary to meet Georgia future water supply needs in addition to the water supply needs to be met by the water supply request. Also, several of the projects currently in the permitting process are outside the Apalachicola-Chattahoochee-Flint (“ACF”) River Basin and are therefore inappropriate for consideration as alternatives to meeting water supply needs inside the ACF River Basin.

Accordingly, and to be as responsive to your request as possible, the State has prepared what we believe is a more useable form of alternatives analysis, a copy of which is attached as Attachment B. As you can see, this analysis relies upon two general premises:

(1) It is not practicable to locate any alternative project for purposes of doing a location-specific economic analysis. Identifying a location for a project requires analysis of countless economic, environmental, and political factors, all of which can create substantial swings in project costs, such that proposing a hypothetical location for a project not currently under consideration renders the resulting analysis so detached from actual, likely costs that the resulting conclusions are not reliable. Therefore, the most meaningful cost analysis that can be done under the present circumstances is evaluation of conceptual, non-specific projects.

(2) The most reliable economic data for use in estimating project costs is that obtained from recently completed and currently planned projects. Again, theoretical values for hypothetical construction details simply do not yield meaningful estimated project costs. Using these costs

creates a range of cost per mgd that would be obtained through the construction of a new reservoir project. Please note that the ranges present in the attached memo represent the low end cost of providing the necessary water supply storage, and the cost of alternative water supply storage could be higher than the estimates in the memo.

Based upon these premises, we have calculated the range of costs for alternatives to water supply allocation from Lake Lanier. Those costs, under several different possible scenarios, along with associated infrastructure costs, are detailed in Attachment B. Again, if you have any questions regarding the attached alternatives analysis, or require further information in that regard, do not hesitate to let us know.

Operational Scenarios for Glades Reservoir

In your February 11, 2011 letter, you request "clarification of potential operational scenarios for the operation of the proposed Glades Reservoir with and without reallocation." As noted in the January 11, 2013 supplement to the water supply request, the State of Georgia projects a 30-40 mgd yield from the Glades Reservoir. As currently proposed, water supply releases from Glades Reservoir will be withdrawn through existing water supply intakes in Lake Lanier. Because the withdrawals from Lake Lanier would be equivalent to the releases from the Glades Reservoir to Lake Lanier, no storage should be required for the withdrawal of that water.

At this time, the State of Georgia is aware of no proposed set of alternative operations for Glades Reservoir in the unlikely event that the Corps denies, in whole or in part, Georgia's water supply request. Should the Corps deny the water supply request, the State will work with the project sponsors to determine whether the project will go forward and, if so, how the project would be operated.

Please let me know if I can be of further assistance in this matter.

Sincerely,



Judson H. Turner
Director

Attachment A

Forsyth	Average Daily Use (mgd)											comments
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2004	
Residential	7.37	8.11	8.17	8.88	8.02	7.31	9.6	10.09	8.07	7.44		
Multi-family Residential												user group not available
Commercial	1.58	1.71	1.62	1.55	1.41	1.4	1.6	1.96	1.4	1.38		
Industrial												user group not available
Institutional												user group not available
Other (Fireline & Hydrant)	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.05	0.04	0.02		
Other (irrigation)	0.35	0.56	0.66	0.62	0.4	0.22	0.93	0.84	0.64	0.6		
Other (sold to other municipalities)	0.03	0.08	0.05	0.08	0.04	0.06	0.1	0.1	0.18	0.15		
Total	9.34	10.47	10.51	11.14	9.88	9	12.26	13.04	10.33	9.59		

Buford	Average Daily Use (mgd)											comments
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2004	
Residential	0.47	0.49	0.48	0.5	0.5	0.49	0.58	0.58	0.61	0.6		
Multi-family Residential												user group not available
Commercial	0.34	0.39	0.38	0.4	0.36	0.42	0.48	0.45	0.43	0.41		
Industrial												user group not available
Institutional												user group not available
Total	0.81	0.88	0.86	0.9	0.86	0.91	1.06	1.03	1.04	1.01		

Cumming	Average Daily Use (mgd)											comments
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2004	
Residential	2.81	2.6	3.27	3.13	2.91	2.71	3.26	3.11	2.72	2.58		
Multi-family Residential												user group not available
Commercial	0.73	0.66	0.78	0.71	0.71	0.66	0.94	1.05	0.87	0.9		
Industrial	1.36	1.2	1.25	1.33	1.18	1.09	1.24	1.37	1.41	1.49		Tyson, Koch, and Northside Foods
Institutional												user group not available

Other (Irrigation, Senior, firelines, etc.)	0.19	0.19	0.03	0.05	0.11	0.06	0.09	0.13	0.26	0.27	
Other (sold to other municipalities)	1.15	3.32	4.53	4.4	4.45	5.12	4.55	4.55	4.38	4.52	
Total	6.24	7.97	9.86	9.62	9.36	9.64	10.08	10.21	9.64	9.76	

Gainesville	Average Daily Use (mgd)											comments
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2004	
Residential	7.09	7.4	7.72	7.76	7.42	7.41	7.93	7.31	7.36	7.64		
Multi-family Residential	1.26	1.28	1.28	1.29	1.3	1.31	1.35	1.3	1.26	1.11		
Commercial	1.86	1.97	2.05	2.05	2.02	1.99	2.25	2.35	2.43	2.5		
Industrial	5.46	5.69	5.86	5.75	5.4	5.2	6.98	7.8	6.5	6.09		
Institutional	0.42	0.45	0.47	0.47	0.46	0.45	0.51	0.53	0.57	0.65	NOTE: Institutional not available 2006-13, pulled out of commercial based on the ratio (18.5%) in the 2004/2005 data	
Other (Irrigation)	0.31	0.35	0.36	0.28	0.17	0.22	0.4	0.37	0.34	0.36	NOTE: Irrigation category not available in 04/05, pulled out of commercial based on ratio (12.7%) from 2006-13 data	
Total	16.4	17.14	17.74	17.6	16.77	16.58	19.42	19.66	18.46	18.35		

Gwinnett	Average Daily Use (mgd)											comments
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2004	
Residential	43.85	45.1	47.59	47.29	45.79	46.05						user group not available prior to 2008
Multi-family Residential												user group not available
Commercial	11.15	11.88	12.04	13.35	12.1	13.35						user group not available prior to 2008
Industrial												user group not available

Institutional (Governmental)	1.36	1.32	1.31	2.24	1.85	2.01							user group not available prior to 2008
Other (Wholesale)	1.87	2.55	2.6	2.82	2.98	3.71							user group not available prior to 2008
Other	5.62	10.86	10.89	9.04	8.56	6.77							Difference between finished water record and metered consumption
Total	63.85	71.71	74.43	74.74	71.28	71.89	86.84	87.41	80.65	82.67			

Attachment B

Memorandum

To: Judson Turner, Director

From: Wei Zeng, Hydrology Unit

Date: May 30, 2014

Subject: Response to Army Corps of Engineers request for additional information dated February 11, 2014 regarding water supply alternatives to reallocation at Lake Lanier

Introduction

By letter dated February 11, 2014, the Mobile District of the U.S. Army Corps of Engineers asked for additional information regarding Georgia's Water Supply Request for Lake Lanier (the Georgia Request). In the Georgia Request, the Governor of Georgia has asked the Corps to reallocate storage in Lake Lanier to provide for direct withdrawals from Lake Lanier of 297 mgd and make releases from Lake Lanier to satisfy a water supply need of 408 mgd in the Chattahoochee River downstream of Buford Dam. The Corps seeks information on the "emergency options" that were discussed in the 2009 Water Contingency Planning Task Force Report (Task Force Report) as water supply alternatives that the State might have to pursue if it were cut off from water supply from Lake Lanier.

The State of Georgia is not planning to implement any alternatives to the water supply that currently is and in the future could be provided by Lake Lanier. Lake Lanier is by far the most cost-effective and environmentally protective alternative for the supply of water to those metro governments located around and downstream of it. But, to respond to the Corps' inquiry, we can provide information in response to the question of which alternatives Georgia would be likely to pursue in the unfortunate and unlikely event that Lake Lanier was not available.

In response to the Corps' letter, Georgia EPD has re-examined the types of water resource projects, namely large non-federal reservoirs or large pumping and piping facilities, that would be needed to provide water supply to those jurisdictions that currently or in the future are projected to withdraw water directly from Lake Lanier. Based upon that analysis, we have more directly responsive and accurate information than the 2009 Task Force Report with which to respond to the Corps' question about alternatives.

Before discussing our methodology, it is important to note that we cannot assess whether the new water supply projects contemplated in this memorandum, particularly the reservoirs, could actually be permitted and constructed; nor can we assess fully at this time what the environmental effects of them would be. That would require actually planning, designing and attempting land acquisition and permitting of the projects. Thus, the State of Georgia cannot guarantee (and the Corps should not assume) that the projects discussed in this report would be available to fill any gap in demand between the State of Georgia's needs and supplies available from Lake Lanier. Assuming that the identified projects could be built, however, we are able to make general estimates of their cost.

The analysis provided in this memo concerns only water supply alternatives for those users that will rely on direct withdrawals from Lake Lanier. It is our understanding that these were the waters supply users about which the Corps most desired information regarding alternatives for the emergency or worst-case scenario in which Georgia's Request were denied. Georgia plans to develop a similar analysis for users that withdraw water from the Chattahoochee River and are dependent on releases from Lake Lanier to make those withdrawals. We will provide you with that analysis when it is available.

Also, we have assumed that the Corps desires information about what are likely to be the least-cost alternatives (though none are low cost by any means) and not necessarily which options could be implemented most quickly. The Task Force Report concluded that alternatives could not be implemented in a three-year period that would fill the shortfall that would have resulted were Judge Magnuson's 2009 ruling actually upheld. That continues to be the case; three years, or probably even five or more, would not be time to implement alternatives that would effectively fill the shortfall that would be created if direct withdrawals from Lake Lanier were not allowed. As imposing an arbitrary and unnecessarily short deadline for Georgia to develop alternatives would only worsen an ill-advised decision not to allow storage in Lake Lanier to be used for direct water supply withdrawal, we have not assumed that such a deadline would be imposed.

Analysis

We have analyzed two scenarios; each assuming that the Corps declines to allocate storage in Lake Lanier to meet Georgia's projected 2040 needs for direct water withdrawals from Lake Lanier (estimated to be 297 mgd). The first scenario assumes that the Corps allocates storage to meet existing levels of water withdrawal (as represented by 2011 data) but declines to allocate storage to meet demands beyond that level. The second scenario assumes that the Corps declines to allocate any storage for direct water supply withdrawals from Lake Lanier beyond the 20 mgd assured by relocation contracts and the 1956 legislation providing storage for Gwinnett County.

For each of the scenarios presented below, we estimate the financial costs associated with what would appear to be the most likely alternatives based on the best information available to us at this time and given the time constraints associated with the Corps' request. In the unlikely and unfortunate event that Lake Lanier would not be available to meet the water supply needs of the local jurisdictions that now or are projected to withdraw directly from Lake Lanier, we anticipate generally that alternatives would involve construction of either new non-federal water supply reservoirs and associated transmission pipelines and other infrastructure, or construction of the infrastructure necessary to pump water from the Chattahoochee River below Lake Lanier and transport it up to users above Lake Lanier. As stated above, the alternative reservoirs are generic and do not represent any project that is currently planned or that has been proposed, and it might not even be possible to obtain federal and state regulatory approvals for them or construct them.

We obtained our data on completed and proposed reservoirs from two types of sources. One is the Georgia Environmental Finance Authority, the state agency that assists in the financing of projects of this type. The other is the local water systems that have developed, or are developing, water supply reservoirs.

It is important to note the various factors indicating that our estimates should be viewed as a lower-bound. For one, as-built project cost data are not published, and we do not assume that such data encompasses all of the actual costs associated with the project. Additionally, there are several reasons to believe that future projects will be more expensive than similar past projects, including inflation generally, increasing scarcity of suitable land, and increasingly stringent environmental regulations (such as instream flow standards that went into effect in 2001, and measures to protect water quality and federally-protected species). Another significant reason to believe that future projects will be more expensive is the need to ensure that the safe yield determinations of future reservoirs reflect the occurrences of the historically severe 2007-2008 drought, which will in turn reduce the safe yield of future projects and require larger reservoirs to meet anticipated future demands.

Scenario 1

In this scenario, we assume that the Corps allocates storage to meet only the existing level of direct withdrawals from Lanier, but no more (i.e., 115 mgd). This would leave a water supply deficit of roughly 182¹ mgd (on an annual average daily flow basis) reflecting the combined

¹ The projected 2040 water supply needs of all users who currently or in the future are projected to withdraw water from Lake Lanier. The sum of these needs is 298 mgd, including 257 mgd projected for City of Gainesville, Forsyth County, City of Cumming, Gwinnett County, and City of Buford, and 41 mgd for entities in Dawson, Lumpkin, White, and Habersham Counties. With a recorded water withdrawal of 115 mgd directly from the lake by existing users in 2011, the increment toward the projected 2040 needs is 183 mgd, as illustrated by Figures 2

water supply needs (beyond 2011 levels of withdrawal) of City of Cumming, Forsyth County, City of Buford, Gwinnett County Water & Sewerage Authority, and City of Gainesville. We contemplate two sub-scenarios, 1A and 1B, representing two different generic alternatives for meeting the needs that would not be provided by direct withdrawal from Lake Lanier.

Sub-Scenario 1A

In this sub-scenario, we make the assumption that a set of water supply reservoirs would need to be developed upstream of Lake Lanier. The location, size, pump capacity, hydrologic information, and safe yield for any individual reservoir cannot be determined without a much more detailed study that would accompany actual pursuit of such an option (in the unfortunate and unlikely event the option were needed).

At this time, we can make only very general assumptions in estimating the total cost of the necessary water supply reservoirs. As discussed above, we estimated the cost of reservoirs generally based upon as-built costs for completed reservoirs and projected costs of reservoirs that have been proposed.

Table 1 contains information for seven water supply reservoirs developed in Georgia since 1999. Safe yields of these projects have been obtained from EPD permit files. The cost of developing each project per million gallons of water per day (mgd) of safe yield (i.e., "unit cost") then was determined. Unless otherwise noted, the 'Total Project Costs' in the table reflect land costs and wetlands mitigation costs but do not include water treatment plant costs if such a plant would be needed in association with development of the reservoir. We also note that those safe yields shown in Table 1 may not take into account the 2007-2008 drought, and may therefore over estimate actual safe yield. To the extent that current safe yields are lower than assumed here, the cost per mgd of safe yield would be higher than shown in Table 1.

According to the information compiled in Table 1, the unit cost (expressed in mgd of safe yield) of developing water supply reservoirs has been increasing steadily, from roughly a half million dollars to \$1.8 million per mgd in 1999, to \$2.8 million in 2007. This increase also can be seen in Figure 1. As noted above, this is likely the result of multiple factors.

through 5 of this memorandum. Georgia's Request asks the Corps to allocate storage to meet 297 mgd of water supply needs. The increment between the current level of withdrawal and this requested amount is 182 mgd.

Table 1 - Costs of Completed Water Supply Reservoirs in the Past 15 Years

Reservoir Name	River Basin	Year of Completion	Safe Yield (MGD)	Total Project Cost	Cost per MGD of Safe Yield
Yellow Creek Reservoir	Coosa	1999	33	\$16,171,200 ²	\$0.49 million
Towaliga Reservoir	Ocmulgee	1999	13.7	\$24,694,278 ³	\$1.8 million
Snake Creek Reservoir	Chattahoochee	2001	13.5	\$19,302,400 ⁴	\$1.4 million
Bear Creek Reservoir	Oconee	2002	53	\$37,669,168 ⁵	\$0.71 million
Yahoola Creek Reservoir	Chattahoochee	2002	5.7	\$13,226,221 ⁶	\$2.3 million
Still Branch Reservoir	Flint	2006	35	\$38,300,000 ⁷	\$1.1 million
Hickory Log Creek Reservoir ⁸	Coosa	2007	36	\$99,000,000 ⁹	\$2.8 million

² Source: Cherokee County Water & Sewerage Authority.

³ Source: Henry County Water & Sewer Authority.

⁴ Source: Carroll County Water Authority.

⁵ Source: Upper Oconee Basin Water Authority.

⁶ Source: Georgia Environmental Finance Authority, Georgia Fund Load Increase memorandum, August 22, 2001.

⁷ Source: City of Griffin Public Works.

⁸ The safe yield and total cost for Hickory Log Creek Reservoir shown in Table 1 are based on the assumption that, per the State of Georgia's January 30, 2013 request for the reallocation of storage for water supply in Lake Allatoona, Cobb County-Marietta Water Authority (CCMWA) is permitted to replenish its current storage account in Lake Allatoona with 100% of the water supply releases made from the Hickory Log Creek Reservoir for the benefit of CCMWA. If CCMWA is unable to operate Hickory Log Creek Reservoir in this manner, the safe yield and

The steady increase in unit cost of developing water supply reservoirs also is reflected in the latest cost estimates of reservoir projects that are under development or going through various stages of regulatory review. Table 2 contains information of three such reservoirs. Presently, the unit cost of developing water supply reservoirs in Georgia has been estimated by those involved in planning them as between \$2.2 million and \$6.2 million per mgd. (Note that these cost estimates do not include costs for building water treatment plants.) The trend of increases in unit cost of developing water supply reservoirs can be seen in Figure 1.

Table 2 - Estimated Costs of Proposed Water Supply Reservoirs

Reservoir Name	River Basin	Safe Yield (MGD)	Total Project Cost	Cost per MGD of Safe Yield
Indian Creek Reservoir	Tallapoosa	18	\$112 million ¹⁰	\$6.2 million
Richland Creek Reservoir	Coosa	35	\$75.7 million ¹¹	\$2.2 million
Glades Reservoir ¹²	Chattahoochee	30 to 40	\$129.9 million	\$3.2 million to \$4.3 million
Hard Labor Creek Reservoir	Oconee	41.4	\$134.9 million ¹³	\$3.3 million

Because the cost ranges in Table 2 are more recent, are consistent with the trend of increasing cost since 1999, are more likely to reflect the effects of recent droughts on safe yields, and account at least to some degree for increasingly stringent environmental requirements, the costs per mgd in Table 2 probably are closer to representing current costs, but even they likely

estimated cost of the reservoir will be significantly different, and the total cost per mgd for Hickory Log Creek Reservoir will likely be much higher than the number shown in Table 1.

⁹ Source: Cobb County Marietta Water Authority.

¹⁰ Source: Carroll County Water Authority.

¹¹ Source: Georgia Environmental Finance Authority, Georgia Reservoir and Water Supply Fund Loan Memo, Governor's Water Supply Program, August 1, 2012.

¹² The safe yield and total cost for Glades Reservoir shown in Table 2 are based on the assumption that water supply releases from Glades Reservoir will be withdrawn from existing intake structures in Lake Lanier. If Glades Reservoir cannot be operated in this manner, the safe yield and estimated cost of the reservoir will be significantly different, and the total cost per mgd for Glades Reservoir will likely be much higher than the number shown in Table 2.

¹³ Source: Walton County.

understate what the actual cost of the generic reservoirs that are assumed in this scenario for reasons discussed above. Thus, if one uses the range associated with the estimated cost of proposed reservoirs (\$2.2 million to \$6.2 million per mgd of water supply development), the range of cost for reservoir construction to address a water supply deficit of 182 mgd would be between **\$400 million** and **\$1.13 billion** but could be significantly higher on account of factors discussed in this memorandum.

In addition, for water stored in the water supply reservoirs to reach the designated users, pipelines and pump stations would have to be constructed. Figure 2 shows a potential reservoir and pipeline configuration for Sub-Scenario 1A. We assumed two sets of pipelines connecting the two generic reservoirs to the existing water treatment plants of the anticipated water supply providers. On the east side of Lake Lanier, we assumed a water supply reservoir (USR1) and a set of pipelines connecting this reservoir to the water treatment plants entities such as Hall County, City of Gainesville, Gwinnett County, and City of Buford. On the west side of Lake Lanier, we assumed another water supply reservoir (USR2) and a second set of pipelines connecting this reservoir with entities such as Forsyth County, City of Cumming, Dawson County, Lumpkin County, White County, and Habersham County. Because of the uncertainty in the spatial location of either water supply reservoir and the potential safe yield at individual reservoirs, we assumed a bidirectional pipeline connecting the two sets of pipes, in the event there were a need for one of the pipelines to provide water to users that are projected to receive water from the other pipeline.

To estimate the cost of piping and pump station construction, we consulted the engineering firm of Brown and Caldwell, which was involved in the development of a portion of the 2009 Task Force Report dealing with potential indirect potable reuse options. Brown & Caldwell created a spreadsheet tool in estimating total piping cost (capital investment and operation and maintenance cost – O&M) of transporting large amounts of water over long distances. Brown & Caldwell has provided the most updated Construction Cost Index, which is used in determining construction cost of pipelines in the spreadsheet tool.

Locations of existing water supply entities are identified by the 2009 Task Force Report. Locations of future water supply providers in Dawson, Lumpkin, White, and Habersham Counties are unknown at this time, and are assumed to be at the current population centers in these counties. Distances between different water supply providers were obtained either from the 2009 Task Force Report or from a direct measurement on a scale 1:500,000 Hydrologic Unit Map developed by United States Geological Survey (USGS). Topographic elevations of water supply providers were obtained from the 2009 Task Force Report or from a direct reading of a Google Earth map. Figure 2 shows the compilation of such information.

Since the exact locations of USR1 and USR2 are unknown at this time, we assumed that they are within a 3-mile distance of the existing Forsyth and Buford water treatment plants. We also assumed that the normal elevation of the reservoirs will be the same as the elevation of Forsyth or Buford, so the static pumping head between the water supply reservoirs and the receiving points is zero. If the elevation is different or the distance is farther than three miles, this could increase the cost, possibly significantly.

Using the Brown & Caldwell tool and the above information, we estimated the size and total project cost, including initial capital investment and a 20-year O&M, of each pipeline. As the size of the pipes change, so do the initial capital investment and the O&M. Through trial and error, a minimum total project cost for each pipeline was estimated. The pipeline sizes and associated costs for all pipelines are shown in Figure 2. The total piping and pumping cost of Sub-Scenario 1A is thus estimated to be **\$717 million but could be significantly higher on account of factors discussed in this memorandum.**

When combined with the cost for reservoir construction, the estimate for the cost of Sub-Scenario 1A is between **\$1.12 billion and \$1.85 billion but could be significantly higher on account of factors discussed in this memorandum.**

Sub-Scenario 1B

Another alternative that is at least theoretically possible in the unfortunate and highly unlikely event that Lake Lanier were not available to meet current and projected needs, would be for local governments to attempt to fill the gap of 182 mgd by withdrawing that quantity of water from the Chattahoochee River downstream of Buford Dam. In this alternative, we assume that no water supply reservoir would be constructed, and instead that the water supply providers that would otherwise withdraw water from Lake Lanier would install intakes in the Chattahoochee River below Lake Lanier and pump water (uphill) to those providers.

The cost of this option would result from piping systems and associated pump stations. We have assumed the location of the pump station to be Georgia Power Company's Morgan Falls Dam. A potential piping configuration is shown in Figure 3.

We assumed an eastern pipeline carrying water to meet the water supply needs of Gwinnett County, City of Buford, Hall County, and City of Gainesville, and a western pipeline to meet the needs of Forsyth County, City of Cumming, Dawson County, Lumpkin County, White County, and Habersham County.

Using the same spatial information and assumptions, we utilized the Brown & Caldwell tool to estimate the size of pipelines and associated minimum total project cost of each section of the pipeline system. The resulting sizes and costs of the system are shown in Figure 3.

The total project cost of the pipeline system is estimated to be **\$1.32 billion but could be significantly higher on account of factors discussed in this memorandum**. In addition, the energy needed to pump water uphill and back to the water supply providers upstream of Buford Dam will certainly exceed the amount of energy generated through Buford Dam, and the energy cost associated with pumping the water back uphill likely exceeds the hydropower value of such water (i.e., the value derived from releasing the water through Buford Dam's turbines rather than allowing the water to be withdrawn from Lake Lanier).

Scenario 2

In this scenario, we assume the very unlikely scenario that the Corps does not grant any allocation of storage in Lake Lanier for direct lake withdrawals other than 20 mgd provided for under relocation contracts and the 1956 Gwinnett County legislation. The 2040 water supply deficit would thus be 277 mgd.

Sub-Scenario 2A

In this sub-scenario, the 277 mgd gap in demand projected for 2040 would be met by two generic non-federal water supply reservoirs upstream of Lake Lanier and a system of pipelines and pump stations to transmit the water from the reservoirs to the water utilities. Figure 4 shows such a reservoir-and-pipeline configuration.

In addition to the caveats mentioned above, we add that it is even less clear that suitable land upstream of Lake Lanier would be available for reservoirs that would be large enough to meet such a high demand, or that such reservoirs would successfully complete the 404 permitting process and be built. Making the assumption that such reservoirs could be built, however, and using the assumption that water supply reservoirs would be constructed with a unit safe yield (mgd) cost of \$2.2 million to \$6.2 million, we estimate that the cost of the reservoirs would be between **\$609 million and \$1.72 billion but could be significantly higher on account of factors discussed in this memorandum**.

Also using the same information and assumptions as we applied in analyzing Sub-Scenario 1A, and applying appropriate pipe sizes and corresponding total project cost of each section of the pipelines, we assumed the cost of the pipelines and pump stations that would be needed for delivery of water from the reservoirs. This information has been compiled and shown in Figure 4. The total project cost of the piping system would be approximately **\$849 million but could be significantly higher on account of factors previously discussed in this memorandum**.

The total project cost of this reservoir-and-pipeline system is therefore estimated to be between **\$1.46 billion and \$2.57 billion but could be significantly higher on account of factors discussed in this memorandum**.

Sub-Scenario 2B

This sub-scenario is similar to 1B, with a much larger water supply deficit being met by a pipeline-only system. We continued to use the assumption that the starting point of the pipeline system would be at Morgan Falls. The other basic information, assumptions, and analytical tools applied to Sub-Scenario 1B also are applied here. Figure 5 shows the configuration. It has been assumed that the 20 mgd the Corps allocated from Lake Lanier storage applies to meet partial demands at the end of the eastern pipeline. Using these assumptions, the total project cost of the pipeline and pump station system is estimated to be approximately **\$1.53 billion but could be significantly higher on account of factors discussed in this memorandum.**

Other Sources of Supply

We are not aware of other sources of replacement supply that are less costly or that would have less impact to the environment than those that we have presented here. Our estimates assume aggressive water conservation and, thus, further conservation is not anticipated to be an alternative to filling the demand gap. It is possible that some combination of the alternatives discussed above (e.g., new reservoirs and piping of water from the Chattahoochee River to the north) might be attempted, but we would anticipate the cost of that combination to be no less, and could be significantly greater, than the above alternatives.

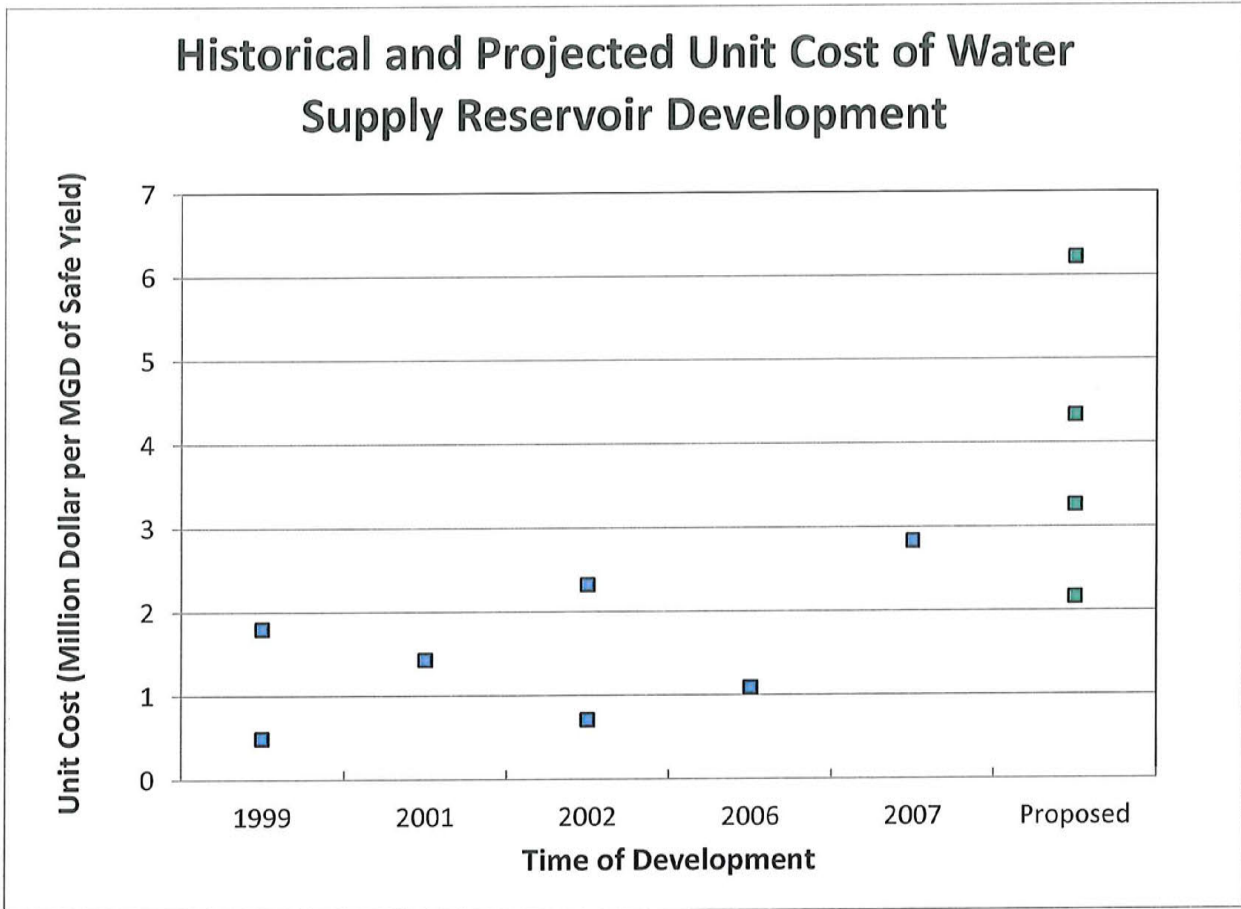


Figure 1. Historical and Projected Unit Cost of Developing Water Supply Reservoirs

Note: Blue squares – Costs of reservoirs that have been built

Green squares – Projected costs of reservoirs that are in planning stage

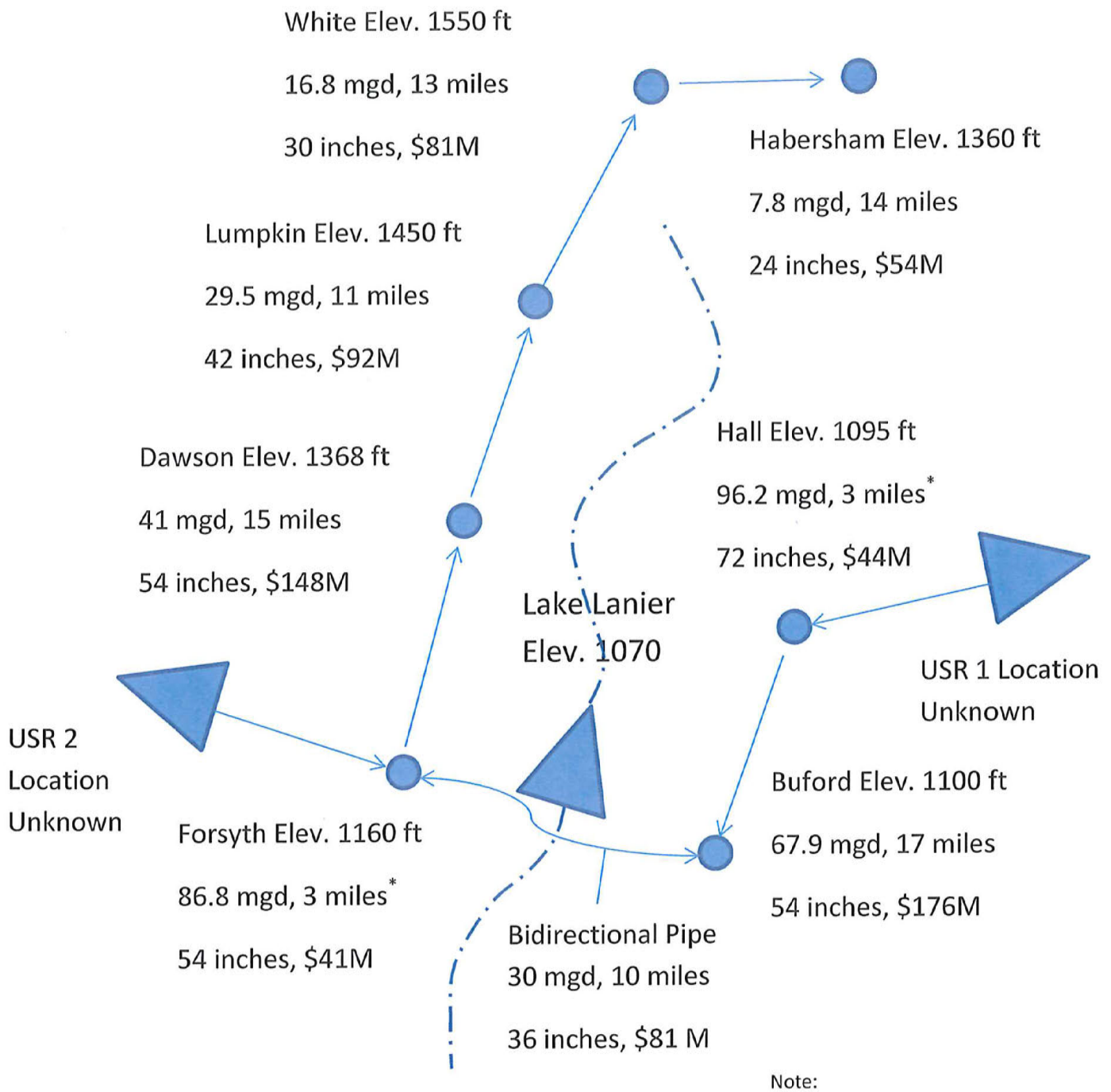
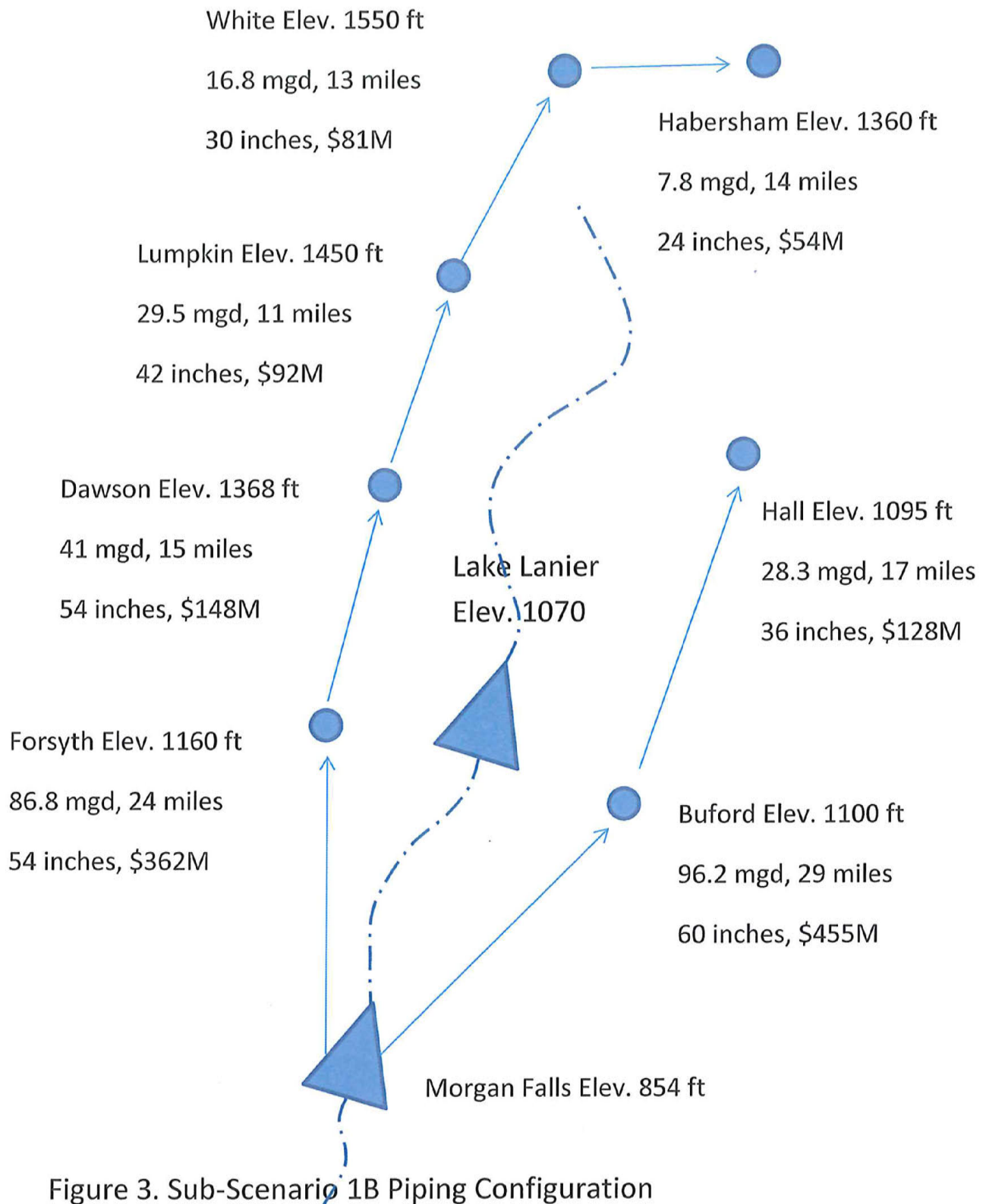


Figure 2. Sub-Scenario 1A Piping Configuration



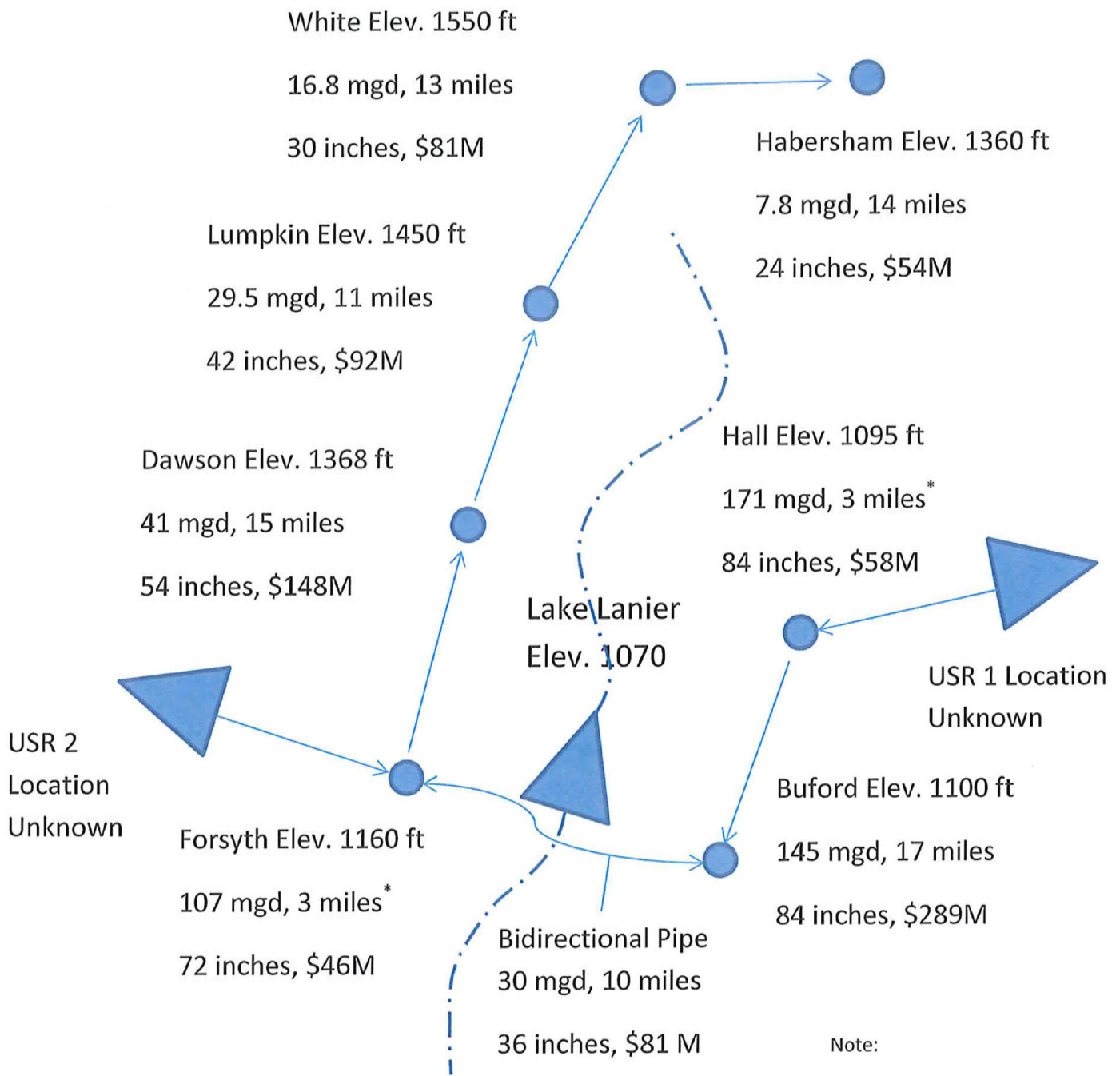
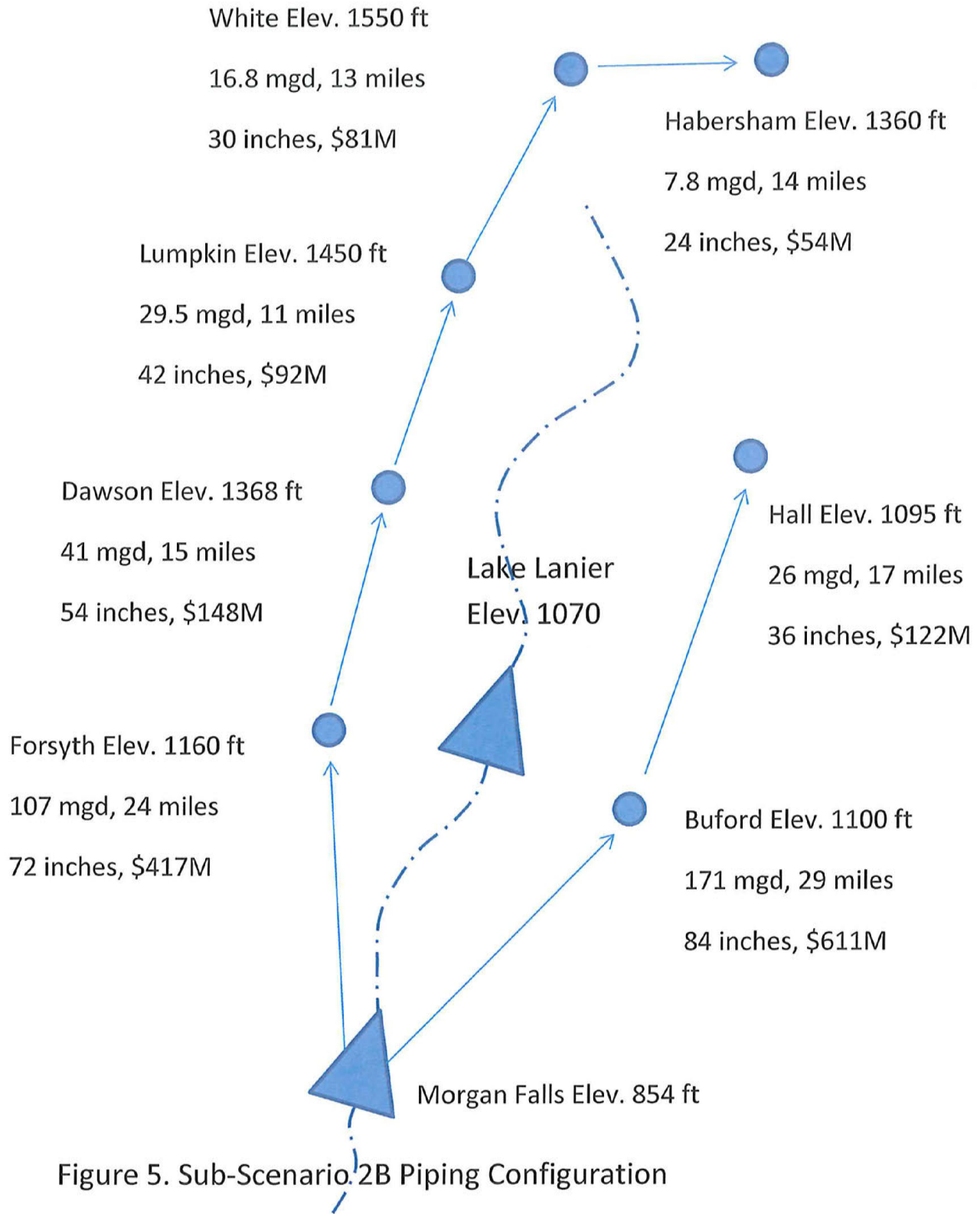


Figure 4. Sub-Scenario 2A Piping Configuration



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1 **Appendix C: Water Supply Storage Assessment Costs Narrative**

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Apalachicola-Chattahoochee-Flint Water Supply Storage Assessment Cost Narrative

Rough Order Magnitude Cost Estimates

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Introduction 1

Project Description 1

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Chattahoochee River Withdrawal and Pumping System Details 3

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1 **Introduction**

2 The purpose of this cost analysis was to provide independent cost estimates for water supply
3 alternatives that could be implemented absent a reallocation from Lake Lanier. These estimates are
4 used as a verification for costs provided by the State of Georgia regarding the two alternatives that were
5 brought forward for the Most Likely/ Least Costly alternative analysis in the Water Supply Storage
6 Assessment

7 **Project Description**

8 The most cost efficient and viable water supply measures to develop alternatives were considered for cost
9 analysis, new reservoirs and Chattahoochee River Withdrawal and Pumping System. Expansion of reservoirs
10 was also heavily considered as a viable option. Due to the lack of data from municipalities and our own (COE)
11 for expansion of reservoirs through raising dam height and converting flood control to water supply, it was
12 decided that expansion of reservoirs would only be explored if new reservoirs construction was justified
13 economically. Some of the measures considered but excluded due to known costs or viability for further
14 analysis are: groundwater and aquifer storage and recovery (ASR), conversion from septic system to sewer,
15 desalination, interbasin transfer.

16 **1. Chattahoochee River Withdrawal and Pumping System**

17 Chattahoochee River Withdrawal and Pumping System entails a pipeline network and pumps to redirect
18 treated wastewater from the natural water (Chattahoochee River) back upstream for drinking water
19 purposes (just south of Lake Lanier). Water discharged from waste water treatment plants along the river is
20 captured at three withdrawal locations and pumped to water treatment plants upstream of the discharge
21 areas. The map found on page 41 of the “Water Contingency Planning Task Force Report – Appendix III” was
22 used as a guide for approximate water reuse withdrawal points and accompanying pipeline location.
23 Elevation profiles were generated along serendipitous pipeline routes (extrapolated from the figures
24 provided in the above reports) to determine the location of the Pump stations needed to carry the water to
25 the furthest points of the map. Analysis was complete to determine the size and pipe material needed to
26 convey the large quantity of water. Exact location of the network or pumping stations are not determined
27 nor were the quantity and complexity of valves, air release valves, surge tanks, pumping system
28 requirements and intake structures technically evaluated at this stage of the process. The estimated scope of
29 the Chattahoochee River Withdrawal and Pumping System network is 155 miles with pump stations along the
30 network providing up to 277 mgd .

31 **2. New Reservoir Construction**

32 The new reservoir construction entails the storage (earthen dam), pipeline and pumping infrastructures.
33 Water treatment facilities were excluded based on the assumption that they can or will be able to handle the
34 additional requested capacity. Yield analysis and locations can not be identified at this stage of the water
35 supply study due to lack of time and funding for further investigations or preliminary designs. Since a size or
36 number of reservoirs is not given without a yield analysis, the information provided within is given based on
37 cost/safe yield mgd. See Cost Methodology for more details.

38

1 **Cost Methodology**

2 There are two measures considered for new water supply, new reservoirs and Chattahoochee River
3 Withdrawal and Pumping System of water. Many other measures (see project description for details) were
4 considered, but eliminated due to the known higher costs and viability.

5 The methodology was very similar for both projects. A Class 5 (parametric) estimate is provided for
6 economic screening. The Class 5 estimate is based on 0-2% project definition using parametric estimating
7 and judgment. These estimates are not location specific; therefore a design, full scope, real estate or
8 environmental conditions are unknown. The estimates identified the appropriate civil works Work
9 Breakdown Structure that include 03 reservoirs, 13 pumping plant, 19 Utilities (Pipelines), 01 Lands and
10 Damages, 30 Planning, Engineering & Design and 31 Construction Management.

11 Each project site is unique; therefore, without specific locations, costs are difficult to capture. A broad
12 parametric estimate was developed for each measure using information/contracts gathered from actual built
13 projects from municipalities or the COE.

14 **1. Price Level**

15 Every contract had different **price levels**. For conceptual purposes and comparisons for parametric
16 estimating, all of the costs were brought to date using CWCCIS tables. These values are “hidden” in the
17 safe yield column. In this case for a Class 5 estimate, without location specific data, **escalation** is the
18 best form of determining current price level costs. CWCCIS accounts used are: (03) Reservoirs, (13)
19 Pumping Plants , (19) Utilities, (30) PED, (31) Construction Management. The CWCCIS tables were not
20 used for the (30) PED or (31) Construction Management Accounts. Instead a percentage was derived
21 from actual costs provided by municipalities then the percentage was applied to the 2014 price level.

22
23 **2. Planning, Engineering, Design**

24 The actual costs provided from municipalities for Still Branch Reservoir, Towaligia Reservoir and Hickory
25 Log Creek Reservoir ranged from 12-17%. A much lower percentage was used for the Reuse due to the
26 high cost and level of complexity.

27
28 **3. Lands and Damages- Real Estate**

29 Real Estate has too many variables to accurately determine a value on conceptual designs. Some of the
30 variables are dependent on zoning, land condition and land use. As part of cost engineering judgment
31 and information provided from Mobile District Real Estate Division the land values have been escalated
32 using data for the State of Georgia from Real Estate U.S. Census Bureau and Lincoln Institute of Land
33 Policy. Instead of using inflation or in many cases deflation from the price level provided to 2014 price
34 level, a more conservative approach was taken. Inflation was determined using the given price level
35 (based on the year of actual land purchase) to the highest point from that given time. For example, Still
36 Branch Reservoir land acquisition was in 1999. Therefore I pulled the value of land for Georgia in the
37 first quarter for 1999. I then pulled the highest value of land from 1999 to 2014 to determine the
38 maximum inflation since 1999. The value would have deflated if I used 2014 value compared to 1999

1 value; therefore the previously detailed conservative approach is taking into account the risks involved
2 in real estate.

3 After consultation with SAM Real Estate Division, it was also assumed that for the potable reuse
4 measure, 1/3 of the easements are within the existing right of way. Real estate costs include 22 acres at
5 \$45,000 per acre and 560 acres of easements at \$22,500 for a total of approximately \$9,400,000.

6

7 **4. Risk Analysis-Contingency**

8 Due to associated risks, the lack of design and use of parametric cost information, it was agreed
9 between the COST MCX and SAD that a contingency amount of 30% can be used for the measures.

10 However, a contingency of 100% was used for 01 Account: Lands and Damages due to the high
11 fluctuations in costs and unaccounted relocations that may be unavoidable.

12 **Chattahoochee River Withdrawal and Pumping System Details**

13 Contracts for 36" and 60" pipelines and pump stations were gathered from COE and municipality history. A
14 wide variety of conditions are within.

15 For the pump stations, Jacksonville and Savannah COE contracts as well as a parametric estimating website
16 were compared. For the pipelines, actual contracts (or part of the contracts) provided by municipalities or
17 COE, most of which are in the surrounding area, were compared and summarized below.

18

- 19 • Still Branch Contract #1 (provided by municipality)
- 20 • SAM Jackson County Water Authority Contract #1
- 21 • SAM Jackson County Water Authority Contract #2 (pipeline partially under river)
- 22 • Pax Newsletter
- 23 • SAM Redstone
- 24 • Level Creek Force Main
- 25 • North Gwinnett Transmission Main
- 26 • Lanier Reuse Lines (provided by
- 27 • Lanier Reuse Lines Contract #2
- 28 • Hickory Log Creek

29

30 Pumping station costs vary considerably, depending on such factors as location, architectural design,
31 capacity, pumping head, distance between stations and many more. It is unreasonable to preclude to a
32 design for all of the mentioned details for a planning class 5 estimate; therefore parametric estimating
33 was executed from a wide variety of projects based, for the most part, on capacity. See Tables 1 and 2
34 for a summary of the data collected and analyses for the cost development of the 36" and 60" pipeline
35 construction. The pumping station costs were based on capacity. The pumping station cost
36 development within the reuse network is summarized in Table 3: Basis of Pumping Stations.

37

Table 1: Basis for 36" pipeline costs

Past Construction Contracts	quantity	unit of measure	construction cost*	\$/in-ft	price level	2014 price level	unit costs
*Still Branch Contract #1partial (36")	43,780	lf	6,200,015		2005	8,053,391	183.95
Jackson County Water Authority (30")Contract 1	31,700	lf	5,574,034		2006	6,909,967	217.98
***Jackson County Water Authority (30")Contract 2	15,840	lf	4,424,283		2006	5,484,654	346.25
Pax Newsletter	1	lf	142		2013	144.698	144.70
Redstone	32,902	lf	32,902		2001	2,438,367	209.36
Level Creek Force Main (36")- Georgia	10,275	lf	2,222,228		2003	3,556,524	346.13
**North Gwinnett Transmission Main (30" & 48")	23,545	lf	8,043,581	8.17	2007	8,270,843	351.28

Average Parametric Unit Cost for 36" pipeline \$257.09

NOTES:

- ** Adjusted for 36" through \$/in-ft
- * took out portions 24" transmission lines
- ***partially under a River
- Redstone provided by Joe Ellsworth
- Jackson County found on shared drive
- Still Branch provided by Municipality
- Level Creek and North Gwinnett provided by Dieter Franz (AE)

1
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Table 2: Basis for 60" pipeline costs

	quantity	unit of measure	construction cost*	price level	2014 price level	Diameter (in.)
Past Construction Contracts						
Lanier Reuse Lines (Steel)	5,500	lf	3,151,259	2003	5,043,375	72
Lanier Reuse Lines (Steel)	720	lf	412,529	2003	660,224	48
Lanier Reuse Lines Contract #2	27,021	lf	24,432,354	2007	29,180,439	70
Pax Newsletter	1	lf	263	2013	268.2008	60
Hickory Log Creek	5,600	lf	2,750,000	2008	3,183,763	42

Average Diameter 65.84

\$/in-ft 14.89

Average Parametric Unit Cost for 60" pipeline	\$893.17
--	-----------------

NOTES:

There is a lack of 60" pipeline contracts therefore a combination of 42-72" pipelines have been evaluated with a \$/in-ft.

Lanier and Hickory Log are projects advertised by Municipalities and provided by Dieter Franz

Table 3: Basis for Pump Stations

based on capacity	capacity (mgd)	No. Pumps	Unit Costs/ (mgd)	price level	2014 price level Unit Costs(\$/mgd)
costwater.com	50	?	113,562	1999	179300
	100	?	87,064	1999	137463
*SAS Montgomery Pump Station	200	4	50000	1999	78944
319	2142	5	12,737	2000	20293
9A	269	4	21,991	2000	35035
362	2260	7	12,880	2000	20521
361	40	3	54,250	2001	86605
382	205	3	49,181	2003	79911
383	22	2	48,240	2003	78382
385	86	4	30,585	2004	50843
357	309	5	33,621	2005	59505
Picayune Strand - Merritt	554	6	82,298	2009	157251
Picayune Strand - Faka	1679	9	40,293	2010	76441
Picayune Strand - Miller	791	8	86,024	2013	170625

Average Parametric Unit Cost for Pump Stations w/ intake structures	\$ 87,937
Average Parametric Unit Cost for Pump Stations w/o intake structures	\$ 70,350

Notes:

* Savannah project provided by Bill Guidry.

projects 4-14 provided by Jacksonville

Intake Structures assumed to be 25% of pump station cost

1

2

- 1 The pipeline and pump station costs developed from recent contracts are used to determine an overall class
- 2 5 estimate from a rough order magnitude scope provided by SAM engineering design team. Table 4 contains
- 3 the pipeline network costs and Table 5 contains the pumping stations costs.

Table 4: ROM Scope and Costs of Potable Reuse Pipeline Network

	Pipeline Location	Length (mi.)	No. Pipes	TOTAL Length (mi.)	TOTAL Length (LF)	
1	Cedar to Bellwood	21.25	5	106.25	561,000	
2	Bellwood to Dekalb	15.3	5	76.5	403,920	964,920
3	Dekalb to PS #1	18	4	72	380,160	
4	Dekalb to PS #2	4.3	4	17.2	90,816	
5	PS #1 to Forsyth	11.5	4	46	242,880	
6	PS #2 to Buford	13.5	4	54	285,120	
7	Buford to Hall	13.2	4	52.8	278,784	1,277,760
8	Lake Jackson to PS #3	24.8	2	49.6	261,888	
9	PS #3 to PS #4	19	2	38	200,640	
10	PS #4 to Buford	8.2	2	16.4	86,592	
11	Buford to Lanier WTP	4.8	2	9.6	50,688	599,808

Assume 60" transmission	1,564,728	LF	@	\$1,397,561,645
Assume 36" transmission	1,277,760	LF	@	\$328,504,406

Total Pipeline Estimated Construction Cost		\$1,726,066,051
	rounded	\$1,726,000,000

- 4
- 5

Table 5: ROM Scope and Costs of Reuse Pumping Stations

	Pipeline Location	hp	Capacity (mgd)	PS Cost/ Segment
1	Cedar to Bellwood	4409	205	18,027,088
2	Bellwood to Dekalb	3190	205	14,421,671
3	Dekalb to PS #1	1772	73	5,135,522
4	Dekalb to PS #2	1802	72	5,065,172
5	PS #1 to Forsyth	1274	73	5,135,522
6	PS #2 to Buford	1908	72	5,065,172
7	Buford to Hall	1120	72	5,065,172
8	Lake Jackson to PS #3	5574	77	6,771,150
9	PS #3 to PS #4	5941	77	5,416,920
10	PS #4 to Buford	3305	77	5,416,920
11	Buford to Lanier WTP	660	77	5,416,920

Total Pump Station Estimated Construction Cost	\$ 80,937,230
	\$ 81,000,000

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1 **New Reservoir Construction Details**

2 Contracts and financial records were provided by cooperating municipalities from the northern Georgia
 3 region for Still Branch (2005), Towaligia(1999) and Hickory Log Reservoirs(2006). ***

4 Averages were determined based on a 2014 price level for each of the features except real estate. The
 5 highest cost was used to remain conservative and reduce some of the risks associated with real estate.

6 Yield Analysis is not verified by the USACE SAM engineering team. Costs are based on the assumption that
 7 the yield will be available for combined projects also without an analysis of the interaction between proposed
 8 measures. Site-specific studies to determine minimum flow would not be beneficial due to time and costs at
 9 this point of the water supply study.

10 No costs are included for water quality issues. It is also assumed that existing water treatment facilities can
 11 handle the additional flow or will be modified regardless of the outcome of this study to handle additional
 12 flow.

13 Table 6 summarizes the averages, but details of the above listed reservoirs are available upon request.

Table 6: 2014 Price Level New Reservoir Construction

Averages	28	safe yield (mgd)	Cost/mgd safe yield	
land acquisition		15,337,291.24	547,760.40	/MGD safe yield
reservoir (earthwork)		\$ 36,537,541.39	1,304,912.19	
pumping stations		13,370,048.10	477,501.72	
pipeline		11,286,286.25	403,081.65	
environmental (wetland mitigation)		3,113,782.25	111,206.51	
PED		10,514,791.75	17%	363,430
Construction Management		2297271.213	4%	87,420
Construction Costs		69,432,296.47		3,295,311.99
TOTAL		82,244,359.43	rounded	3,300,000.00

14
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 17

1 **Conclusion**

2 The Chattahoochee River Withdrawal and Pumping System that can supply 277 mgd will cost
 3 approximately \$2.57 billion. The reservoir construction costs are based on an average 28 mgd safe yield
 4 reservoir; therefore the total construction cost would be approximately \$128 million. Since the costs
 5 are so highly variable for reservoir construction, it is better to express the costs per mgd safe yield. With
 6 that being said, one could expect the new reservoir construction to be approximately \$4.56 million per 1
 7 mgd safe yield. Tables 7 and 8 summarize the Rough Order Magnitude (Class 5) estimates for both
 8 measures described.

9 If any option is deemed viable from the economic analysis, further details will be explored to provide an
 10 estimate supported by further investigations, preliminary designs, appropriate risk analysis, total project
 11 cost summary and MCACES estimate.

12

13

14

15

16 **TABLE 7 - SUMMARY OF CHATTAHOOCHEE RIVER WITHDRAWAL AND PUMPING SYSTEM ROM COST**
 17 **(2014 PRICE LEVEL)**

18 WBS No.	Description	UOM	Total
19			
20	19. PIPELINE NETWORK	LS	\$1,726,000,000
21	CONTINGENCY	30%	518,000,000
22			
23	13. PUMPING STATIONS	LS	\$81,000,000
24	CONTINGENCY	30%	24,000,000
25			
26			
27	01. LANDS AND DAMAGES	LS	\$9,400,000
28	Land acquisition and ROW easements		
29	CONTINGENCY	100%	9,400,000
30			
31			
32	30. PLANNING, ENGINEERING AND DESIGN	LS	\$90,000,000
33	CONTINGENCY	30%	27,000,000
34			
35	31. CONSTRUCTION MANAGEMENT	LS	\$63,000,000
36	CONTINGENCY	30%	20,000,000
37			
38			
39	TOTAL PROJECT COST FY-2014		\$ 2,567,800,000

40

**TABLE 8 - SUMMARY OF RESERVOIR ROM COST
(2014 PRICE LEVEL- BASED ON 1 MGD SAFE YIELD)**

WBS No.	Description	UOM	Total
03.	RESERVOIRS	LS	\$1,305,000
	CONTINGENCY	30%	391,000
13.	PUMPING PLANTS	LS	\$881,000
	CONTINGENCY	30%	264,000
01.	LANDS AND DAMAGES	LS	\$547,800
	Land acquisition and ROW easements		
	CONTINGENCY	100%	547,800
30.	PLANNING, ENGINEERING AND DESIGN	LS	\$395,000
	CONTINGENCY	30%	119,000
31.	CONSTRUCTION MANAGEMENT	LS	\$87,000
	CONTINGENCY	30%	26,000
TOTAL PROJECT COST FY-2014		\$ 4,563,600/1 MGD SAFE YIELD	

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Appendix D: Hydropower Analysis Report

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ACF HYDROPOWER IMPACT ANALYSIS DRAFT

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Prepared by
The Hydropower Analysis Center

For



US Army Corps
of Engineers®
Mobile District

August 5, 2015

1 **ACF HYDROPOWER IMPACT ANALYSIS DRAFT**

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1 Introduction

2 This chapter presents an analysis of the effects on hydropower benefits that are
3 expected to result from proposed changes to system water control operations within the
4 Apalachicola-Chattahoochee-Flint (ACF) River Basin. The system hydropower benefits
5 for energy and capacity were computed for the baseline condition, representing current
6 water control operations, and for nine alternative flow scenarios associated with the
7 recommended ACF Water Control Plan described in previous chapters of this
8 Environmental Impact Statement (EIS). The calculations of hydropower energy and
9 capacity benefits are based on a 72-year simulation period (1940-2011) using the HEC-
10 ResSim model.

11 To understand how system operations can effect hydropower generation we will first
12 consider the mathematics used to approximate the amount of power produced from a
13 hydropower facility, the power equation (Eq. 1). This equation shows that power is
14 directly proportional to three variables; the efficiency of the plant turbines, the amount of
15 flow going through the turbines, and the head, the height of the water in the reservoir
16 relative to its height after discharge.

$$17 \quad P = e * g * Q * H \quad \text{Eq. 1}$$

18 Where P=power (kw), e=turbine efficiency, g=gravitational constant (m/s²), Q-flow
19 (m³/s), and H=head (m).

20 Reservoir operations can affect all three of these variables. Higher or lower operational
21 reservoir elevations change the head. Maximum or minimum flow requirements used
22 for flood risk management and environmental purpose can affect the flow. Although
23 power is linear in both head and flow, this relationship quickly becomes non-linear with
24 the inclusion of efficiency which is both a non-linear function of head and flow.

25 In general the hydropower benefits resulting from generation can be divided into two
26 components: energy benefits and capacity benefits. A change in energy benefits is the
27 result of a change in the amount of water that is available to pass through the turbines.
28 The value of this benefit changes both daily and seasonally as a function of the systems
29 electrical load. For example energy may be more valuable during the height of the
30 summer heat while businesses and residents are attempting to cool their environments
31 as opposed to the fall or winter when air conditioners maybe turned off. The capacity
32 benefit is a measure of the amount of capacity that the project can reliably contribute
33 towards meeting system peak power demands.

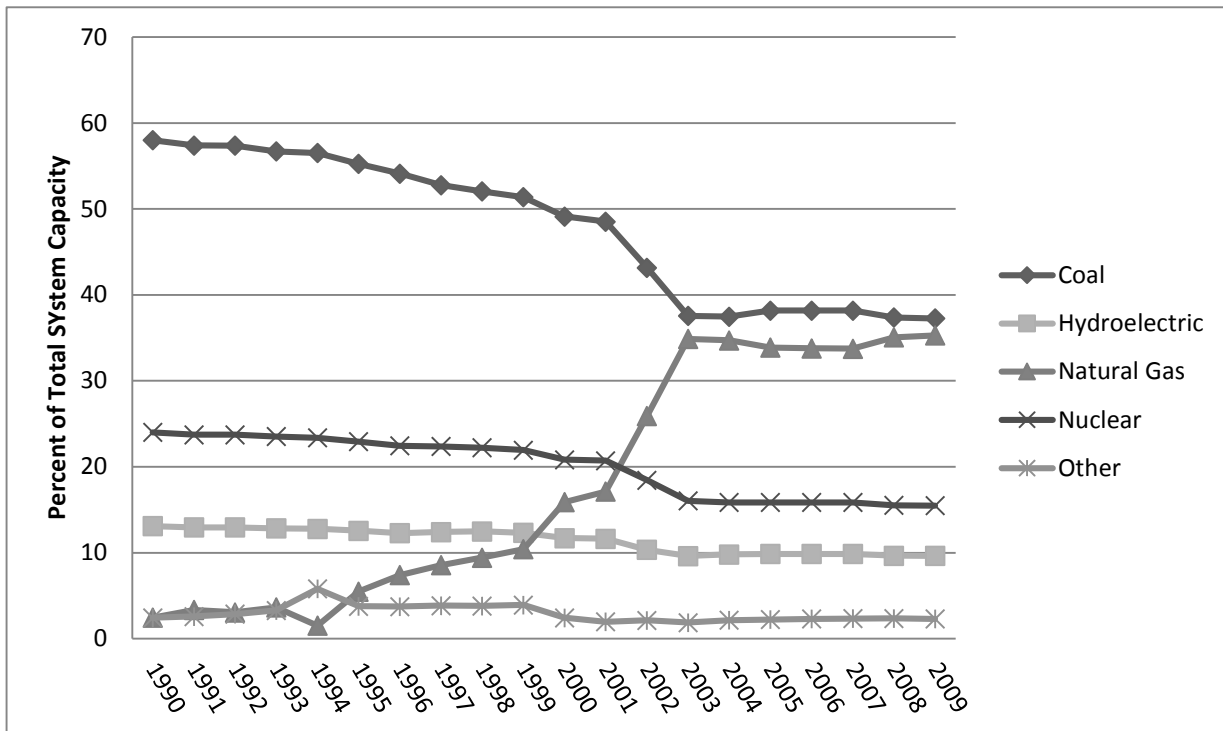
34 The value of the hydropower benefits calculated in this chapter is based upon the cost
35 of utilizing the most likely alternative source for power. For example, if an operational
36 strategy reduces hydropower storage or flow, the loss in energy benefits is equivalent to
37 the cost of replacing the lost power with the most likely alternative source of power. In

1 addition it may decrease the amount of capacity that the hydropower plant can
2 contribute to the peak system load, making it necessary to replace this lost capacity with
3 a thermal alternative.

4 This chapter contains the following: 1) an overview of the Bulk Power System for the
5 ACF River Basin with an emphasis on hydropower 2) a descriptive analysis of the
6 potential annual and seasonal changes in hydropower production due to water control
7 management decisions, and 3) a description of the process of calculating the changes
8 in the energy and capacity benefits of the ACF System resulting from the
9 implementation of the recommended plan.

10 **ACF BULK POWER SYSTEM DESCRIPTION**

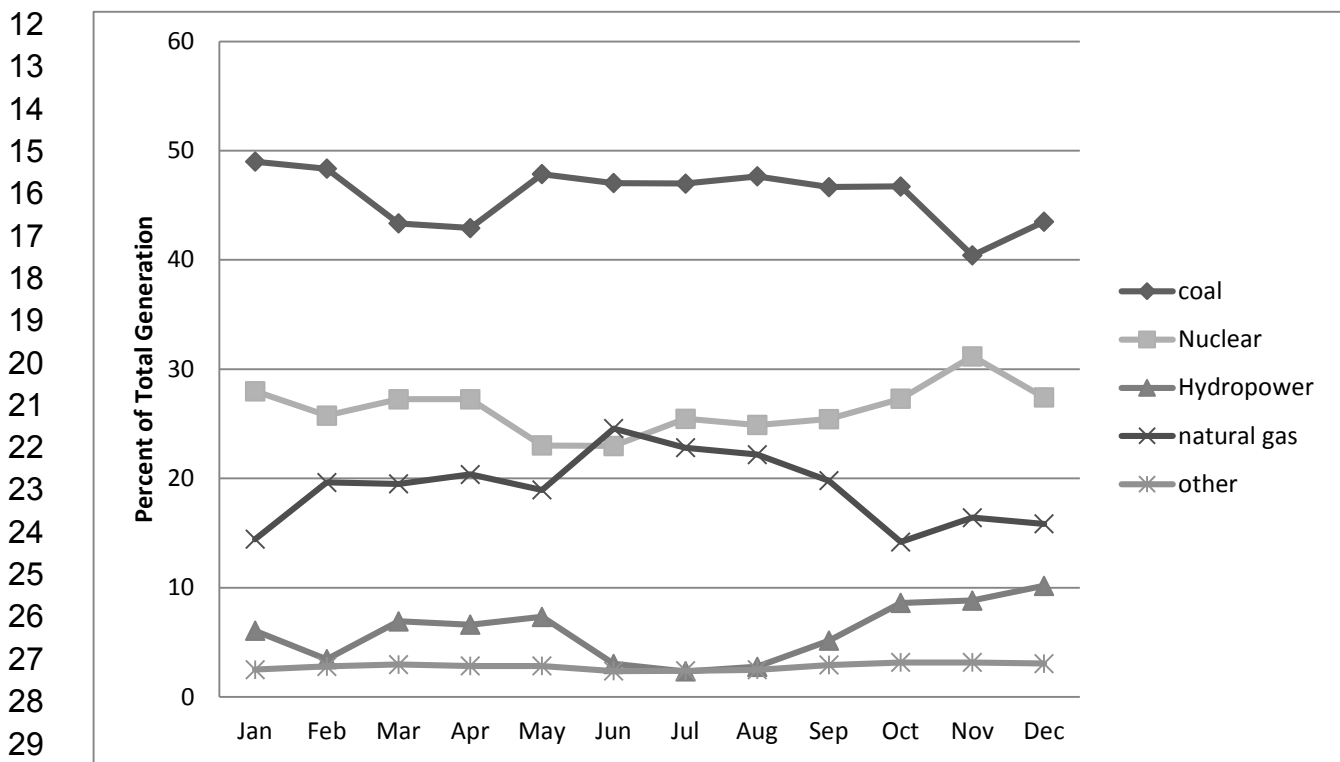
11 The ACF Watershed lies primarily in the southeastern sub-region of the Southeastern
12 Reliability Corporation (SERC). This corporation is responsible for promoting and
13 improving the reliability related to the critical infrastructure of the bulk power system in
14 the region. Since 1998, the southeastern sub-region has undergone a significant
15 increase in natural gas capacity. Natural gas currently nearly matches coal in
16 percentage of total system capacity at around 35 percent. Nuclear and hydroelectric
17 energy make up the remaining bulk energy with 15 percent and 10 percent of total
18 system capacity respectively. (Figure 1)



19

20 **Figure 1. Historical trends for the percent of total system capacity for the**
21 **southeastern sub-region of SERC**

1 Coal and nuclear power are predominately run as baseload plants, facilities that
 2 produce constant rates of generation to meet the systems continuous regional
 3 demands. Natural gas and hydropower plants on the other hand are generally run as
 4 peaking plants, meeting the daily and seasonal peak loads throughout the system. This
 5 is important in conceptually understanding what alternative thermal plants might be
 6 used to replace hydropower if changes in operations dictated such a need. As an
 7 illustrative example consider the 2009 monthly generation pattern (Figure 2) reported by
 8 the Energy Information Administration (EIA) for the southeastern sub-region. Increases
 9 (decreases) in percent of total generation for hydropower are matched by decreases
 10 (increases) in percent generation for natural gas. The same coupling of energy sources
 11 can be seen in the relationship between coal and nuclear power.



30 **Figure 2. Percent of total generation by fuel type for southeastern sub-region of SERC**

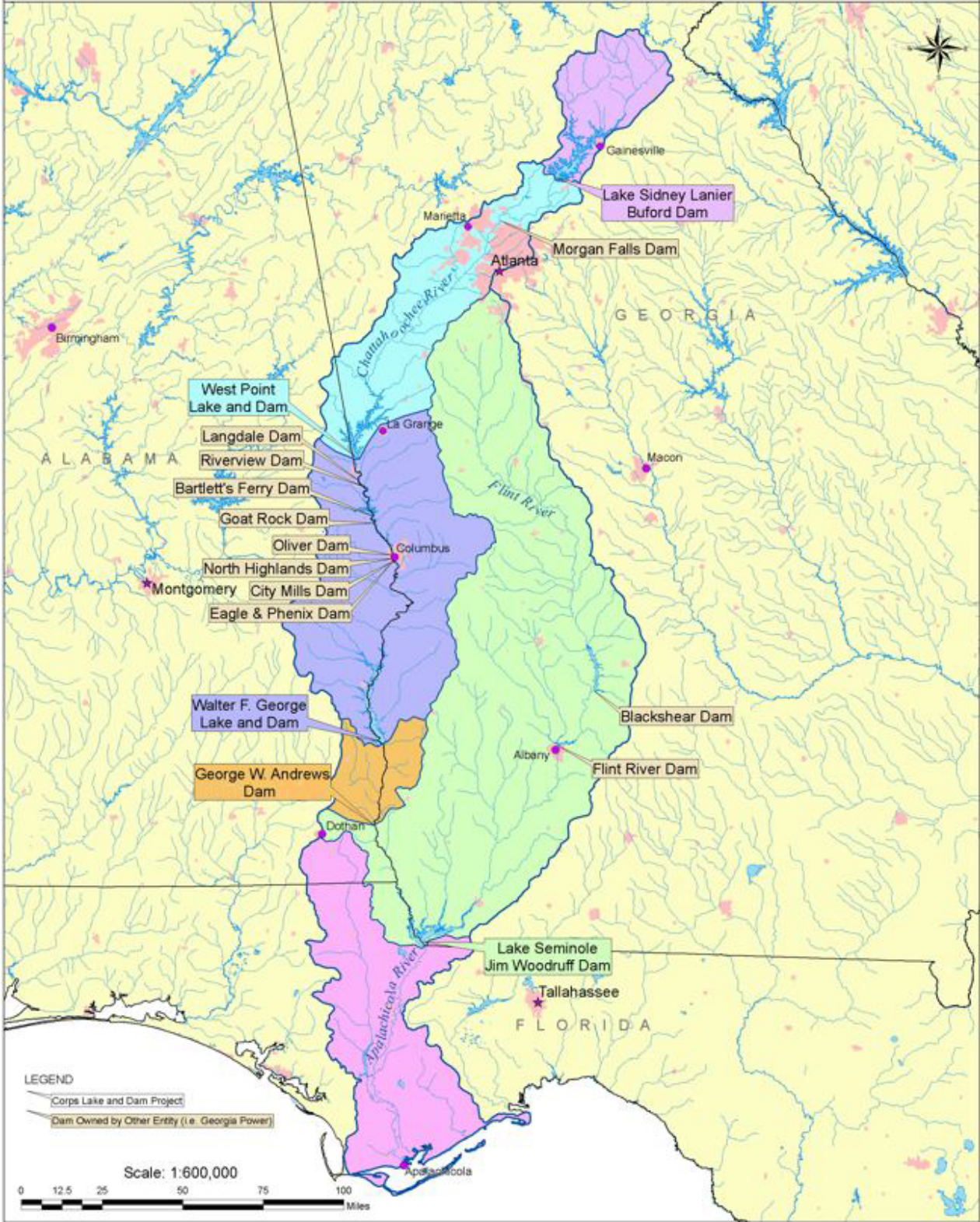
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1 **ACF HYDROPOWER SYSTEM DESCRIPTION**

2 The U.S. Army Corps of Engineers (Corps) operates four dams with hydropower
3 capabilities in the ACF River Basin: Buford Dam, West Point Dam, Walter F. George
4 Lock and Dam, and Jim Woodruff Lock and Dam. Buford Dam, West Point Dam and
5 Walter F. George Lock and Dam are operated as peaking plants with an installed
6 capacity of 381 megawatts (MW) while Jim Woodruff Lock and Dam, located near the
7 confluence of the Chattahoochee and Flint Rivers, is operated as a run-of-river plant
8 with an installed capacity of 43.3 MW. Buford and West Point Dams both have small
9 units, generally used for system station service, that are excluded from the plant's
10 combined nameplate capacity and Reservoir Simulation model (ResSim) simulation.

11 Five non-Corps plants owned by Georgia Power Company (GPC) are also considered
12 in this analysis. Morgan Falls, Barlett's Ferry, Goat Rock, Oliver, and North Highlands
13 (listed in downstream order) all act as modified run-of-river plants. The GPC plants
14 utilize small amounts of storage to help re-regulate the variable releases of the
15 upstream Corps reservoirs. These plants have a combined installed capacity of 342.9
16 MW.

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38 **Figure 3. Map of Hydropower Facilities in the ACF Basin**

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1 Table 1 provides specific plant level details. In this table an individual plant is described
 2 by three different capacity terms, each playing a different role in the analysis. The
 3 nameplate capacity describes the actual amount of capacity installed for the plant
 4 according to the turbine manufacturers and does not account for limits imposed by other
 5 power train equipment. The maximum or operating capacity describes the maximum
 6 capacity at which a plant can operate based on the turbines running at full gate, the
 7 adjustment of the turbine to utilize maximum capacity instead of maximum efficiency.
 8 This value varies slightly depending on factors such as head and cooling capabilities.
 9 This is the capacity assumed in the ResSim model. Finally, the marketable capacity is
 10 meant to describe the amount of capacity available during the heavy load periods of
 11 summer months during extreme hydrological conditions such as a drought. For the
 12 Federal plants, the marketable capacity was confirmed by Southeastern Power
 13 Administration (SEPA), while for the GPC plants nameplate capacity (reference
 14 <http://www.georgiapower.com>) was assumed for both operating and marketable
 15 capacity.

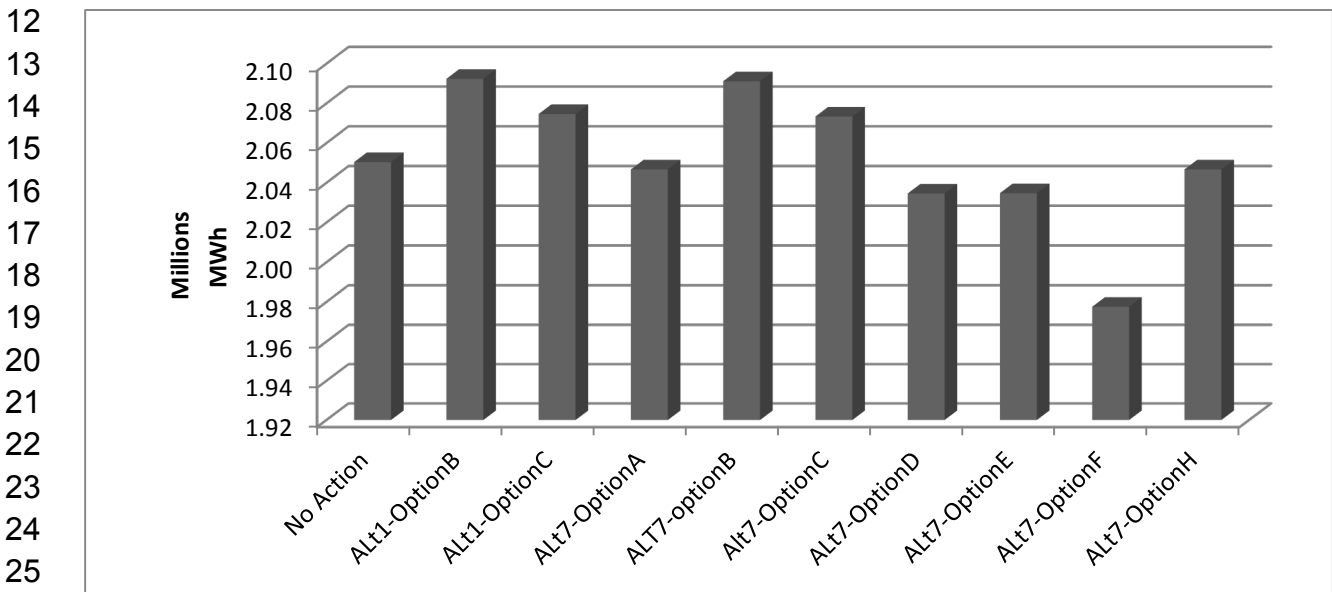
16 **Table 1. Plant Characteristics for Corps and Non-Corps Hydropower Plants**

Plant	Owner	No. of Units	(Installed) Capacity (MW)	Operating Capacity (MW)	Marketable Capacity (MW)
Buford Dam	USACE	3	125	116.5	105
Morgan Falls	GPC	7	16.8	16.8	16.8
West Point Dam	USACE	3	88	85.5	75
Bartletts Ferry	GPC	6	197.9	198.6	197.9
Goat Rock Dam	GPC	6	26	40.04	26
Oliver Dam	GPC	4	60	60	60
North Highlands	GPC	4	29.6	35.2	29.6
Walter F. George	USACE	4	168	167.6	150
Jim Woodruff L&D	USACE	3	43.3	43.2	36

17

1 Average Annual Hydropower Generation

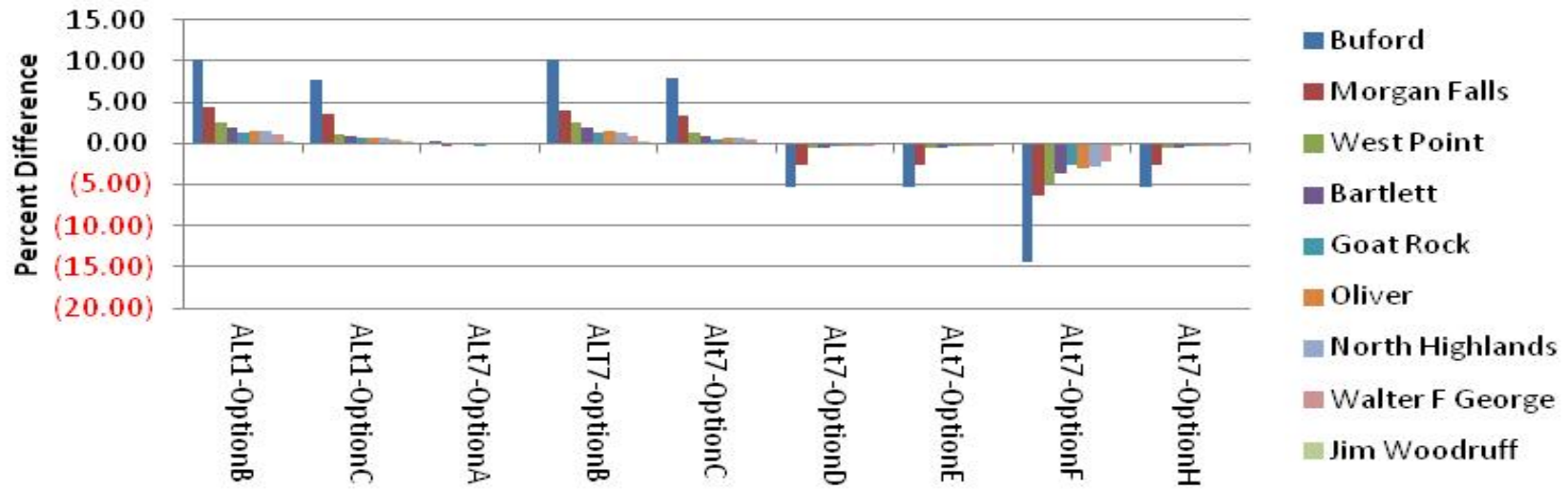
2 To determine the change in energy generation resulting from implementation of the
3 recommended ACF Water Control Plan, an analysis was performed to determine the
4 average annual energy generated for the nine alternatives. The Option B alternatives
5 for both ALT1 and ALT7 alternatives have the most average annual generation with
6 over 2.08 million MWh of generation. The Alt7-OptionF alternative has the least with
7 only around 1.97 million MWh of annual generation (Figure 4). However, the value of
8 the replacement energy has a seasonal trend following the demand and generating
9 resource availability through the year. Therefore, in calculating annual benefits, it is
10 necessary to look at how the generated energy is distributed on a monthly basis. This
11 is method is discussed in the next section.



26 **Figure 4. Average Annual Hydropower System Generation by Alternative**

27 Figure 5 shows both the percent difference between the No Action alternative and the
28 remaining eight alternatives broken down by plants. In all cases the magnitude of the
29 difference reduces significantly downstream from Buford Dam. For both ALT1 and
30 ALT7, the Options B and C alternatives showed a percent increase in annual generation
31 when compared to the No Action alternative for almost all plants. The remaining
32 options for the ALT7 alternatives all showed a percent loss when compared to the No
33 Action alternative, with most loss coming from Buford and Morgan Falls Dams. Only the
34 Option F shows significant losses for all hydropower plants.

Annual Generation Percent Difference Compared to No Action ALternative



1

2 **Figure 5. Annual Generation Percent Difference compared to no action alternative broken down by plants**

3

1 **Energy Benefits:**

2 Energy benefits are computed as the product of the energy loss in megawatt-hours and
3 an energy unit value price (\$/MWh). The energy price is based on the cost of energy
4 from a combination of thermal generating plants that would replace the lost energy from
5 the hydropower plant due to operational and/or structural changes.

6 **Energy Price Computation:**

7 This analysis uses a simulation over the period of record to estimate the effects of
8 changes in water management on hydropower production. However, in order to
9 evaluate the resulting changes in hydropower benefits over a 50-year period of analysis,
10 forecasts of future energy prices are needed. These forecasted prices also need to
11 reflect seasonal variation of both peak and off peak prices.

12 **Energy Price Data Used:**

13 To estimate regional future energy prices that reflect both seasonal and peak and off-
14 peak variation two sources of data are required. The first data source is the EIA long-
15 term energy forecast, while the second data source is the system λ values reported in
16 the Federal Energy Regulatory Commission (FERC) Form 714 reports.

17 ***EIA historical and long term forecast:***

18 Future and historical energy values in this analysis are based on EIA forecasts from the
19 supplemental tables of “Annual Energy Outlook” (AEO 2013). The EIA forecasts are
20 developed with the Electricity Market Model (EMM) as part of the National Energy
21 Modeling System (NEMS). The following description is from the model documentation
22 report available on the EIA website:

23 *The National Energy Modeling System (NEMS) was developed to provide 20-to-*
24 *25-year forecasts and analyses of energy-related activities. The NEMS uses a*
25 *central database to store and pass inputs and outputs between the various*
26 *components. The NEMS Electricity Market Module (EMM) provides a major link*
27 *in the NEMS framework (Figure 1). In each model year, the EMM receives*
28 *electricity demand from the NEMS demand modules, fuel prices from the NEMS*
29 *fuel supply modules, expectations from the NEMS system module, and*
30 *macroeconomic parameters from the NEMS macroeconomic module. The EMM*
31 *estimates the actions taken by electricity producers (electric utilities and*
32 *nonutilities) to meet demand in the most economical manner. The EMM then*
33 *outputs electricity prices to the demand modules, fuel consumption to the fuel*
34 *supply modules, emissions to the integrating module, and capital requirements to*
35 *the macroeconomic module. The model iterates until a solution is reached for*
36 *each forecast year.*

1 In addition to providing average annual energy forecasts of electrical generation prices
2 through 2040, AEO 2013 also includes regional forecasts corresponding to North
3 American Electric Reliability Corporation (NERC) regional entity sub-regions. Federal
4 ACF hydropower plants are located in the southeastern sub-region of the Southeastern
5 Reliability Corporation (SERC/S). Discussions with SEPA confirmed that most of the
6 electrical generation from ACF plants is marketed through SERC/S, and that EIA
7 forecasts of thermal generation prices for the SERC/S region was appropriate for this
8 analysis.

9 **System Lambda:**

10 Because EIA provides only a single average energy value for each future year through
11 2040, the EIA forecasts values are used to shape system λ values acquired from the
12 Federal Energy Regulatory Commission (FERC) Form 714 reports. For utilities
13 generating electricity from thermal plants, Form 714 requires reporting of hourly energy
14 demand (load) and the hourly marginal cost (lambda) of generating one additional MW
15 of electrical energy.

16 The following explanation of how lambda was calculated is from the FERC Form 714
17 report, Part II, Schedule 6, filed for 2010 by Southern Company:

18 *The Southern Company system lambda is determined hourly and is based on the*
19 *variable costs of the resources that serve the load obligations of the Operating*
20 *Companies plus any sales to third parties. The variable costs of the resources*
21 *include the components listed below, and may also reflect the cost of purchases.*
22 *The economic dispatch formula used to dispatch Southern's generating*
23 *resources on the basis of their variable cost components is as follows:*

24
$$\lambda = [\{ (2aP + b) * (FC + EC) \} + VOM + FH] * TPF$$

25 *Where:*

26 λ = System lambda

27 a, b = Incremental heat rate coefficients

28 P = Generation level

29 FC = Marginal replacement fuel costs

30 EC = Marginal replacement emission allowance costs

31 VOM = Variable operations and maintenance expenses

32 FH = In-plant fuel handling expenses

33 TPF = Incremental transmission losses (penalty factors)

1 Form 714 reports are available online for the five Southern Company utilities that
 2 generate thermal power in SERC/S for the years 2008 through 2012: Alabama Power,
 3 Georgia Power, Gulf Power, Mississippi Power, and Southern Power. The five
 4 Southern Company utilities represent about three quarters of the fossil fuel generating
 5 capacity in the SERC/S sub-region and about 92 percent of the fossil generation for
 6 which system lambda is reported to FERC. While system lambda and load were also
 7 reported during this period by Southern Mississippi Electric Power Cooperative and
 8 Alabama Electric Cooperative, formatted data from these companies was not available
 9 for the entire period and therefore was not included in the calculations described below.

10 **Methodology for energy price shaping:**

11 To forecast the system λ using the EIA forecasted generation values the following ratio
 12 is assumed:

13
$$\frac{\lambda_{Future}}{\lambda_{Past}} = \frac{EIA_Generation_{Future}}{EIA_Generation_{Past}}$$

14 This can be rewritten as:

15
$$\lambda_{Future} = EIA_Generation_{Future} * \frac{\lambda_{Past}}{EIA_Generation_{Past}}$$

16 Future system λ values can then be computed by the product of the EIA generation
 17 forecast and a shaping ratio defined as:

18
$$ShapingRatio = \frac{\lambda_{Past}}{EIA_Generation_{Past}}$$

19 To replicate the peak and off peak variation, daily system λ values are sorted from high
 20 to low and are averaged using the peak and off peak periods described in the Energy
 21 Benefits Calculation section below. Seasonal variability is taken into account by
 22 computing shaping ratios for each month. These shaping ratios are computed as
 23 averages among dates with like month and peak and off-peak classification using the
 24 equation:

25
$$ShapingRatio(\text{Peak/offpeak designation, month}) = \text{Average} \left(\frac{\lambda_{Past}(\text{Peak/offpeak designation, month})}{EIA_Generation_{Past}(\text{year})} \right)$$

1
2

Table 2. Peak and Off-peak Shaping Factors for SERC'S sub-region using Southern Company System λ values

	peak	off peak
Jan	0.92	0.60
Feb	0.79	0.58
Mar	0.74	0.56
Apr	0.75	0.53
May	0.76	0.54
Jun	0.98	0.64
Jul	1.00	0.67
Aug	0.87	0.61
Sep	0.76	0.56
Oct	0.72	0.55
Nov	0.68	0.52
Dec	0.70	0.54

3 The proportions in Table 2 were then multiplied by the EIA forecast energy value for
4 each year to obtain estimates of monthly on-peak and off-peak values. To develop the
5 annualized prices for each calendar month, the present values of on-peak and off-peak
6 prices for each month of the 50-year period of analysis were calculated using the
7 Federal discount rate of four percent. The resulting 50 present values were then
8 summed and amortized over the 50-year period of analysis at the Federal discount rate.
9 The resulting annualized prices are shown in Table 3.

10
11

Table 3. Average Annual On-Peak and Off-Peak Energy Prices by Month (2015 \$)

	Peak	Off-Peak
January	\$57.51	\$37.49
February	\$49.39	\$36.40
March	\$46.42	\$35.26
April	\$46.82	\$33.27
May	\$47.58	\$34.01
June	\$61.56	\$40.10
July	\$62.30	\$41.77
August	\$54.24	\$37.85
September	\$47.60	\$34.92
October	\$44.85	\$34.43
November	\$42.55	\$32.81
December	\$43.71	\$33.46

1 **Energy Benefit Calculations:**

2 Although all plants in this system are defined as peaking plants the actual hydropower
 3 operations of the individual power plants can vary significantly. For example some
 4 plants may turn completely off and then back on again during peak demand periods,
 5 while others may have a minimum flow requirement that constantly generates a small
 6 amount of electricity with a maximum generation occurring during peak demand
 7 periods. Unfortunately, the detailed hourly generation information required from each
 8 plant to determine the daily peak and off peak percentage of total generation is not
 9 available. To calculate the energy benefits, the method assumes that plants will
 10 operate to maximize energy benefits; that is, to generate the maximum amount of
 11 energy during periods of peak demand.

12 The Southeastern Power Administration (SEPA) confirmed the seasonal variation of
 13 peak hours for the region. Eleven daily peaking hours were defined for the winter
 14 period from October 1 through March 31: 5:00 a.m. to 9:00 a.m. and 3:00 p.m. to 10:00
 15 p.m., Monday through Friday. Six daily peaking hours were defined for the summer
 16 period from April 1 through September 30: 1:00 p.m. to 7:00 p.m., Monday through
 17 Friday. The maximum daily amount of peak generation for each plant was then defined
 18 as the product of the number of daily peaking hours times the installed capacity of the
 19 plant.

20 Tables 4 and 5 shows each plants average annual energy benefits under the nine
 21 alternative flow scenarios separated by Federal and Non-Federal plants. Table 6 shows
 22 the aggregate total energy value of both Federal and Non-Federal Plants.

23 **Table 4. Individual Plant and Total System Energy Benefits for Federal Plants (2015 \$)**

	Buford	West Point	Walter F George	Jim Woodruff	Total Federal Energy Value
No Action	\$5,852,881	\$7,915,638	\$20,567,901	\$10,306,584	\$44,643,004
ALt1-OptionB	\$6,416,667	\$8,099,794	\$20,772,634	\$10,323,045	\$45,612,140
ALt1-OptionC	\$6,265,432	\$8,003,086	\$20,665,638	\$10,313,786	\$45,246,914
ALt7-OptionA	\$5,834,362	\$7,889,918	\$20,519,547	\$10,289,095	\$44,531,893
ALt7-OptionB	\$6,401,235	\$8,091,564	\$20,741,770	\$10,305,556	\$45,540,123
Alt7-OptionC	\$6,258,230	\$7,994,856	\$20,635,802	\$10,299,383	\$45,188,272
ALt7-OptionD	\$5,522,634	\$7,865,226	\$20,495,885	\$10,297,325	\$44,181,070
ALt7-OptionE	\$5,522,634	\$7,866,255	\$20,495,885	\$10,297,325	\$44,182,099
ALt7-OptionF	\$5,001,029	\$7,557,613	\$20,152,263	\$10,267,490	\$42,978,395
ALt7-OptionH	\$5,519,547	\$7,865,226	\$20,494,856	\$10,297,325	\$44,175,926

1 **Table 5. Individual Plant and Total System Energy Benefits for Non-Federal Plants (2015 \$)**

	Morgan Falls	Bartlett	Goat Rock	Oliver	North Highlands	Total Non-Federal Energy Value
No Action	\$2,715,021	\$18,039,095	\$8,051,440	\$10,098,765	\$5,659,465	\$44,562,757
ALt1-OptionB	\$2,818,930	\$18,353,909	\$8,147,119	\$10,231,481	\$5,729,424	\$45,279,835
ALt1-OptionC	\$2,805,556	\$18,186,214	\$8,095,679	\$10,160,494	\$5,693,416	\$44,942,387
ALt7-OptionA	\$2,698,560	\$17,996,914	\$8,019,547	\$10,063,786	\$5,639,918	\$44,418,724
ALt7-OptionB	\$2,806,584	\$18,338,477	\$8,128,601	\$10,212,963	\$5,717,078	\$45,204,733
Alt7-OptionC	\$2,794,239	\$18,174,897	\$8,078,189	\$10,141,975	\$5,681,070	\$44,871,399
ALt7-OptionD	\$2,648,148	\$17,944,444	\$8,015,432	\$10,050,412	\$5,635,802	\$44,294,239
ALt7-OptionE	\$2,649,177	\$17,945,473	\$8,016,461	\$10,051,440	\$5,635,802	\$44,298,354
ALt7-OptionF	\$2,558,642	\$17,429,012	\$7,851,852	\$9,824,074	\$5,515,432	\$43,179,012
ALt7-OptionH	\$2,648,148	\$17,944,444	\$8,016,461	\$10,050,412	\$5,635,802	\$44,294,239

2 **Table 6. Total System Energy Benefits (Federal and Non-Federal plants) (2015 \$)**

	Federal Energy Value	Non-Federal Energy Value	Total
No Action	\$44,643,004	\$44,562,757	\$89,205,761
ALt1-OptionB	\$45,612,140	\$45,279,835	\$90,891,975
ALt1-OptionC	\$45,246,914	\$44,942,387	\$90,189,300
ALt7-OptionA	\$44,531,893	\$44,418,724	\$88,950,617
ALt7-OptionB	\$45,540,123	\$45,204,733	\$90,744,856
Alt7-OptionC	\$45,188,272	\$44,871,399	\$90,059,671
ALt7-OptionD	\$44,181,070	\$44,294,239	\$88,475,309
ALt7-OptionE	\$44,182,099	\$44,298,354	\$88,480,453
ALt7-OptionF	\$42,978,395	\$43,179,012	\$86,157,407
ALt7-OptionH	\$44,175,926	\$44,294,239	\$88,470,165

3 **Capacity Benefits:**

4 Capacity benefits are defined as the product of the change in dependable capacity and
 5 a capacity unit value, which represents the capital cost of constructing replacement
 6 thermal capacity.

7 The dependable capacity of a hydropower project is a measure of the amount of
 8 capacity that the project can reliably contribute towards meeting system peak power

1 demands. If a hydropower project always maintains approximately the same head, and
2 there is always an adequate supply of stream flow so that there is enough generation
3 for the full capacity to be usable in the system load, the full installed generator capacity
4 can be considered dependable. In some cases even the overload capacity is
5 dependable.

6 At storage projects, normal reservoir drawdown can result in a reduction of capacity due
7 to a loss in head. At other times, diminished stream flows during low flow periods may
8 result in insufficient generation to support the available capacity in the load.

9 Dependable capacity accounts for these factors by giving a measure of the amount of
10 capacity that can be provided with some degree of reliability during peak demand
11 periods.

12 **Dependable Capacity Calculation Procedure:**

13 Dependable capacity can be computed in several ways. The method that is most
14 appropriate for evaluating the dependable capacity of a hydropower plant in a
15 predominantly thermal-based power system, like the ACF River Basin, is the average
16 availability method. This method is described in Section 6-7g of EM 1110-2-1701,
17 Hydropower, dated 31 December 1985. The occasional unavailability of a portion of a
18 hydropower project's generating capacity due to hydrologic variations should be treated
19 in the same manner as the occasional unavailability of all or part of a thermal plant's
20 generating capacity due to forced outages.

21 In order to evaluate the average dependable capacity for a project, a long-term record
22 of project operation must be used. Actual project operating records would be most
23 desirable; however, certain factors may preclude the use of these records. The period
24 of operation may not be long enough to give a statistically reliable value. Furthermore,
25 operating changes may have occurred over the life of the project, which would make
26 actual data somewhat inconsistent. In order to assure the greatest possible consistency
27 in this calculation, the 50-year ResSim simulation for the ACF River Basin was used.

28 The dependable capacity calculation procedure for the ACF River Basin projects began
29 by approximating each project's contribution (weekly hours operating on peak) in
30 meeting the system capacity requirements demand for the regional critical year. This
31 contribution estimate was determined by first calculating each project's weekly average
32 energy produced (MWh) for the peak demand months of mid-May through mid-
33 September of 1981, the critical year from the ResSim baseline model run. This number
34 was then divided by SEPA's defined marketable capacity (MW). This gave an estimate
35 of weekly hours on peak for each project. Coordination with SEPA confirmed
36 marketable capacity values for the Corps hydropower plants and the critical water year
37 of 1981. Installed capacity was assumed for all non-Corps plants.

1 Next, each project’s weekly average energy (MWh) produced during the peak demand
 2 months was calculated for each simulated year. Dividing these values by each project’s
 3 weekly average hours (H) on peak determined in the previous step, yielded an array of
 4 yearly dependable capacity values. The average across the array is each project’s
 5 average dependable capacity.

6 This process is repeated for the baseline and the three alternative flow scenarios using
 7 the ResSim model runs. The total system difference between the three flow scenarios
 8 and the baseline condition is the gain or loss in dependable capacity caused by
 9 changes in system water control operations. These results for the Federal plants are
 10 shown in Table 7. The results for the Non-Federal plants are shown in Table 8. The
 11 aggregate Federal and Non-Federal dependable capacity is shown in Table 9.

12 **Table 7. Plant and System Dependable Capacity Calculations for Federal Plants**

Capacity (MW)	Buford	West Point	Walter F George	Jim Woodruff	Federal Dependable Capacity Total
No Action	110.78	82.91	163.02	39.59	396.29
ALt1-OptionB	112.64	83.24	162.89	39.66	398.44
ALt1-OptionC	112.82	83.05	163.06	39.60	398.53
ALt7-OptionA	108.74	83.01	163.48	39.55	394.78
ALT7-optionB	110.28	82.94	163.39	39.51	396.13
Alt7-OptionC	111.59	83.30	163.48	39.57	397.94
ALt7-OptionD	108.75	83.21	163.54	39.57	395.06
ALt7-OptionE	108.52	83.17	163.54	39.56	394.78
ALt7-OptionF	104.78	82.90	163.53	39.51	390.72
ALt7-OptionH	108.55	83.17	163.54	39.56	394.81

13

1 **Table 8. Plant and System Dependable Capacity Calculations for Non-Federal Plants**

Capacity (MW)	Morgan Falls	Bartlett	Goat Rock	Oliver	North Highlands	Non-Federal Dependable Capacity Total
No Action	16.47	197.58	38.96	55.95	32.68	341.63
ALt1-OptionB	16.59	197.41	33.39	56.35	32.02	335.76
ALt1-OptionC	16.64	197.83	39.00	55.85	32.71	342.04
ALt7-OptionA	16.35	197.72	38.96	55.77	32.68	341.47
ALT7-optionB	16.42	196.78	33.29	56.17	31.92	334.58
Alt7-OptionC	16.56	198.11	39.03	55.91	32.74	342.36
ALt7-OptionD	16.37	197.98	39.02	55.88	32.73	341.98
ALt7-OptionE	16.37	197.92	39.01	55.86	32.73	341.88
ALt7-OptionF	16.31	197.57	38.94	55.74	32.68	341.24
ALt7-OptionH	16.37	197.91	39.01	55.86	32.73	341.88

2 **Table 9. Total System Dependable Capacity (Federal and Non-Federal PLants)**

	Federal Dependable Capacity	Non-Federal Dependable Capacity	Total
No Action	396.29	341.63	737.92
ALt1-OptionB	398.44	335.76	734.20
ALt1-OptionC	398.53	342.04	740.57
ALt7-OptionA	394.78	341.47	736.26
ALt7-OptionB	396.13	334.58	730.70
Alt7-OptionC	397.94	342.36	740.30
ALt7-OptionD	395.06	341.98	737.04
ALt7-OptionE	394.78	341.88	736.67
ALt7-OptionF	390.72	341.24	731.96
ALT7-OptionH	394.81	341.88	736.69

3 **Capacity Unit Value Calculation**

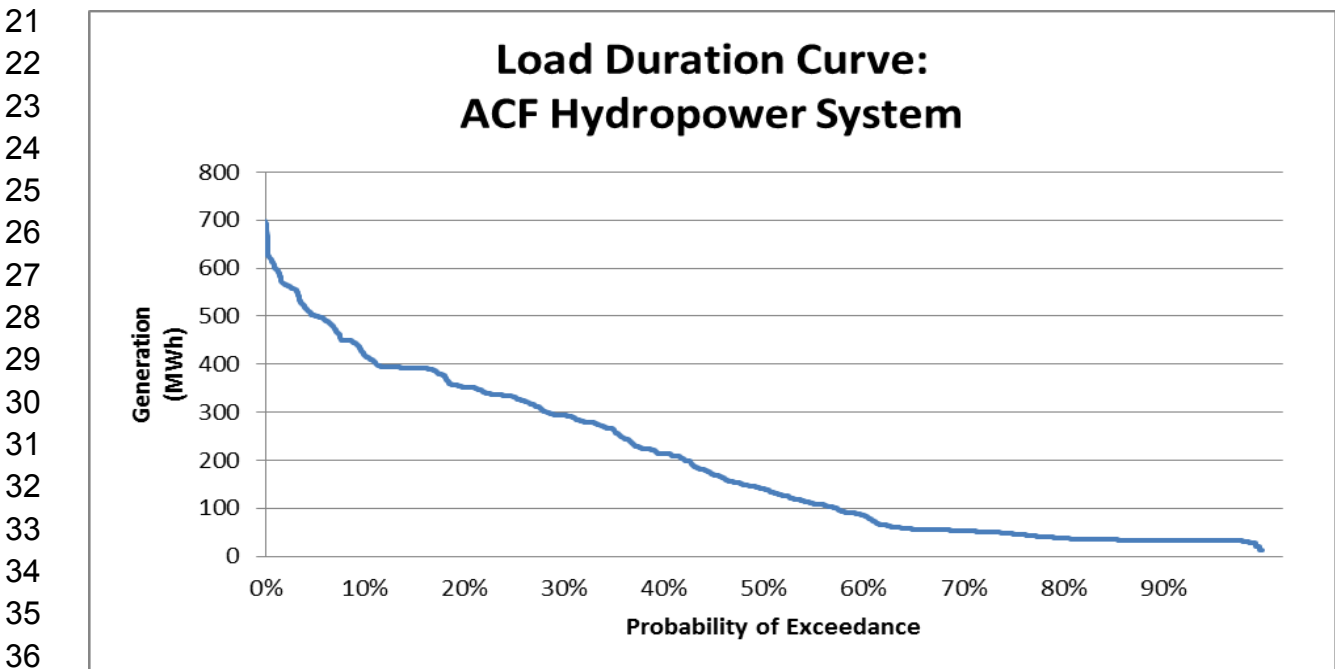
4 Capacity unit values represent the capital cost and the fixed O&M cost of the most likely
5 thermal generation alternative that would carry the same increment of load as the
6 proposed hydropower project or modification. As discussed below in the screening
7 curve analysis description, the cost effectiveness of the different thermal resources
8 depends on how and when the resource is used. For example, coal fired plants may be
9 used to replace a base loading hydropower plant while a gas fired turbine plant may be
10 used to replace a peaking hydropower operation. A combined cycle plant would be
11 used in an intermediate mode of load-following. In this section the process of
12 determining the least costly, most likely combination of thermal generation resources,

1 which comprise the thermal alternative to hydropower, is described. Also, the method
2 calculating the capacity unit value is presented.

3 **Typical Hourly System Generation**

4 To establish the most likely thermal alternative, an analysis of how the hydropower
5 system is currently operated is performed. The goal of this analysis is to show how
6 much capacity can be defined as base load, how much can be defined as intermediate
7 load, and how much can be defined as peaking. Typically the process of computing a
8 capacity value is done on a plant by plant basis, however the necessary data, hourly
9 generation for a typical year was only available for the four USACE plants. In this
10 regard, a total system typical hourly generation exceedance curve is developed.

11 To produce the total system exceedance chart, two assumptions were made. First, the
12 non-USACE plants acted similar in operation to the four USACE plants. This
13 assumption is reasonable since the non-Corps plants are similarly defined as peaking
14 plants like the USACE facilities. Secondly a further assumption was made that the
15 USACE hydropower plants' typical year occurred concurrently. With these assumptions
16 the typical hourly generations for the USACE plants were combined and then divided by
17 the Total nameplate capacity of all four USACE plants. This allows for an exceedance
18 curve for percent of nameplate capacity. This can then be made to represent the entire
19 system by simply multiplying the y-axis of the load duration curve by the total system
20 capacity of ACF System (Figure 6).



37 **Figure 6. Load duration curve for ACF Watershed Hydropower System**

1 **Screening Curve Analysis**

2 A screening curve is a plot of annual total plant costs for a thermal generating plant
3 [fixed (capacity) cost plus variable (operating) cost] versus annual plant factor. When
4 this is applied to multiple types of thermal generation resources, the screening curve
5 provides an algebraic way to show which type of thermal generation is the least cost
6 alternative for each plant factor range.

7 The screening curve assumes a linear function defined by the following equation:

8
$$AC = CV + (EV * 0.0876 * PF)$$

9 where: AC = annual thermal generating plant total cost (\$/kW-year)

10 CV = thermal generating plant capacity cost (\$/KkW-year)

11 EV = thermal generating plant operating cost (\$/MWh)

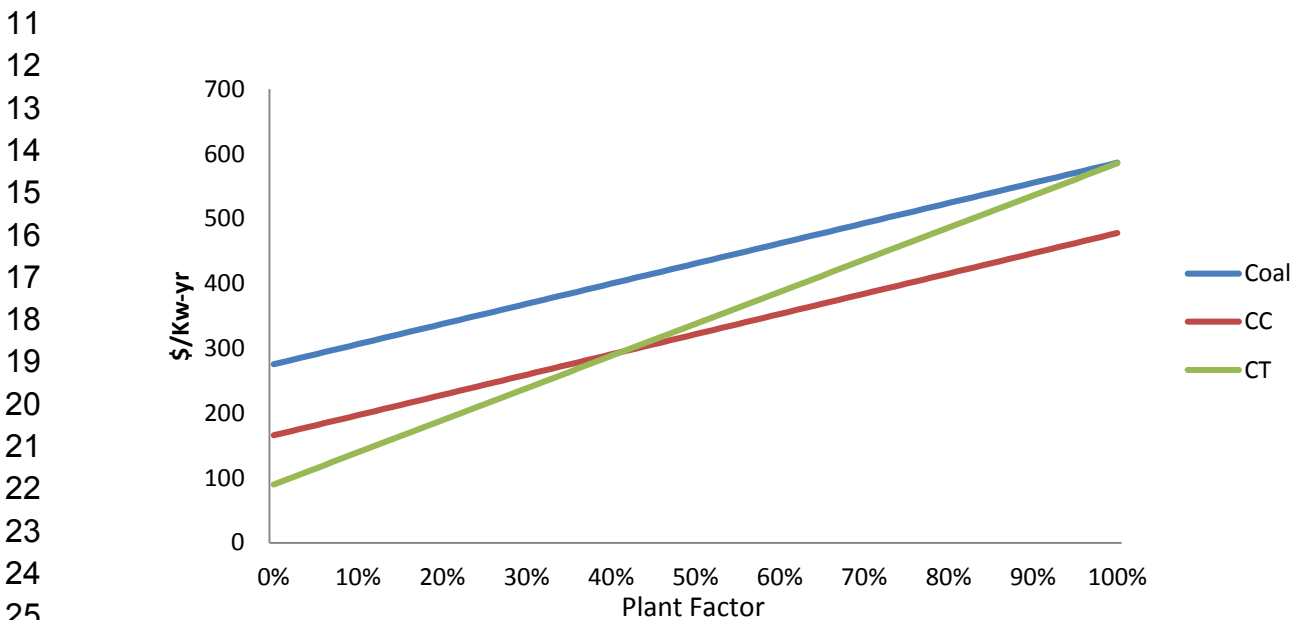
12 Capacity unit values for coal-fired steam, gas-fired combined cycle and combustion
13 turbine plants were computed using procedures developed by the Federal Energy
14 Regulatory Commission (FERC). Capacity values were computed for the SEPA region
15 based on a 3.5 percent interest rate and 2013 price levels. Adjusted capacity values
16 are shown in Table 10. The adjusted capacity values incorporate adjustments to
17 account for differences in reliability and operating flexibility between hydropower and
18 thermal generating power plants. See EM 1110-2-1701, Hydropower, Section 9-5c for
19 further discussion of the capacity value FERC adjustments.

20 **Table10. Adjusted Capacity and Operating Costs for SEPA Region (2013\$)**

Thermal Generating Plant Type	Adjusted Capacity Cost	Operating Cost
	\$/KW-Year	\$/MWh
Coal-Fired Steam	\$275.49	\$35.51
Combined Cycle	\$165.77	\$35.65
Combustion Turbine	\$90.06	\$56.57

1 Operating costs for coal-fired steam, gas-fired combined cycle and gas-fired combustion
 2 turbine plants were developed using information obtained from the publication *EIA*
 3 *Electric Power Monthly (DOE/EIA-0226)* and other sources. The information obtained
 4 included fuel costs, heat rates and variable O&M costs. The resulting values, based on
 5 2013 price levels, are shown in Table 10. Since current Corps of Engineers policy does
 6 not allow the use of real fuel cost escalation, these values were assumed to apply over
 7 the entire period of analysis.

8 The plot for each thermal generation type was developed by computing the annual plant
 9 cost for various plant factors ranging from zero to 100 percent. The plots are shown in
 10 Figure 7.



26 **Figure 7. Regional Screening Curve for Various Thermal Alternatives in the SEPA Region**

27 **Composite Unit Capacity Value**

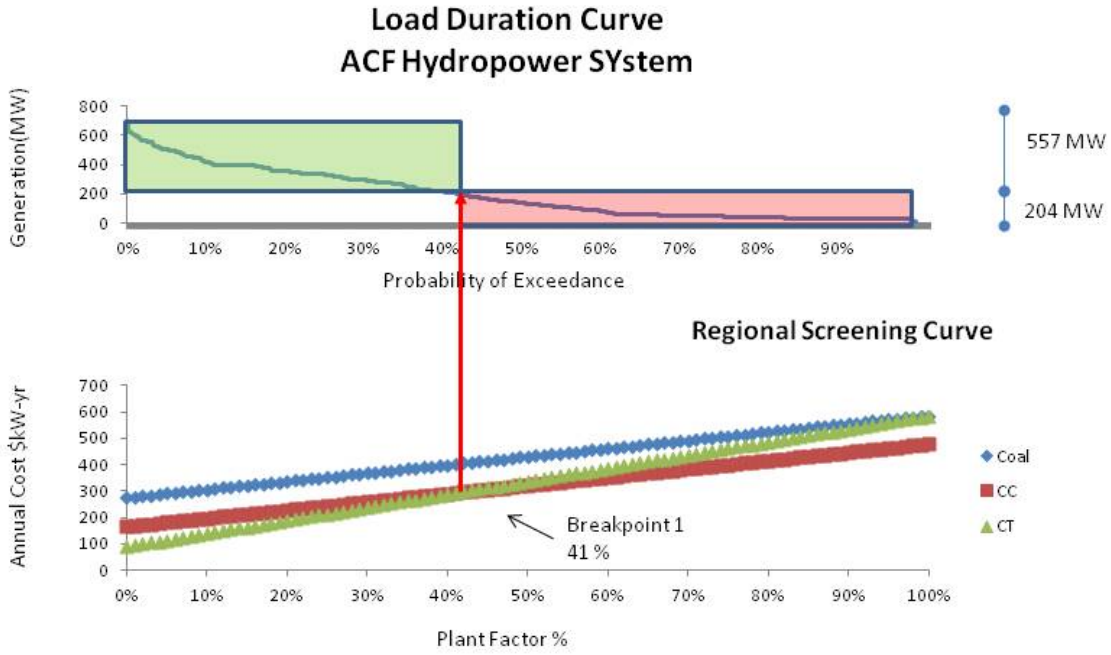
28 The process for calculating the composite unit capacity value for the ACF River Basin
 29 system is described by the following algorithm and is illustrated in Figure 8.

30 Composite Unit Capacity Algorithm:

31 The following is the algorithm used to compute composite unit capacity.

- 32 1. From the screening curve, determine the “breakpoints” (the plant factors at
 33 which the least cost plant type changes).
- 34 2. Find the points on the generation-duration curve where the percent of time
 35 generation is numerically identical to the plant factor breakpoints defined in

- 1 the preceding step; these intersection points define the portion of the
- 2 generation that would be carried by each thermal generation plant type.
- 3 3. Calculate percent of total generating capacity for each thermal alternative
- 4 using the portions defined in step 2.
- 5 4. Calculate the composite unit capacity of the system as an average of each
- 6 the thermal alternative's capacity cost weighted by their percent of total
- 7 generating capacity defined in step 3.



8
9 **Figure 8. Illustrative Example of Composite Unit Capacity Value for ACF River**
10 **Basin Hydropower System**

1 The composite unit capacity values are computed for ACF River basin system is
 2 calculated in Table 11.

3 **Table 11. Composite Unit Capacity Value for ACF System**

	Estimated Replacement Capacity (MW)	Percentage of total Generating Capacity (MW)	Capacity Cost (\$/KW-yr)	Weighted Value (\$)
Total System				
Combustion Turbine	556.68	0.73	90.06	\$65.93
Combined Cycle	203.76	0.27	166.77	\$44.69
Coal	0	0	275.49	\$0.00
			2013 \$	\$110.61
			2015 \$	\$113.81
				weighted average (\$/KW-yr)
				weighted average (\$/KW-yr)

1 **Dependable Capacity Value**

2 The dependable capacity value is computed as the product of the systems dependable
 3 capacity (MW) and the composite unit capacity value (\$/MW) that reflects the most likely
 4 thermal alternative shown in Table 11. Table 12 shows the Total System Dependable
 5 Capacity Values rounded to the nearest 1000\$.

6 **Table 12. Total System Dependable capacity Values (Federal and Non-Federal plants) (2015 \$)**

	Capacity Value \$/MW-yr (2015 \$)	Federal Dependable Capacity	Federal Dependable Capacity Value	Non-Federal Dependable Capacity	Non-Federal Dependable Capacity Value	Total (round to nearest \$1000)
No Action	\$113,801	396.29	\$45,098,373	341.63	\$38,877,986	\$83,976,000
ALt1-OptionB	\$113,801	398.44	\$45,343,046	335.76	\$38,209,972	\$83,552,000
ALt1-OptionC	\$113,801	398.53	\$45,353,288	342.04	\$38,924,645	\$84,278,000
ALt7-OptionA	\$113,801	394.78	\$44,926,533	341.47	\$38,859,778	\$83,787,000
ALt7-OptionB	\$113,801	396.13	\$45,080,165	334.58	\$38,075,686	\$83,155,000
Alt7-OptionC	\$113,801	397.94	\$45,286,145	342.36	\$38,961,061	\$84,248,000
ALt7-OptionD	\$113,801	395.06	\$44,958,397	341.98	\$38,917,817	\$83,876,000
ALt7-OptionE	\$113,801	394.78	\$44,926,533	341.88	\$38,906,436	\$83,833,000
ALt7-OptionF	\$113,801	390.72	\$44,464,499	341.24	\$38,833,603	\$83,298,000
ALt7-OptionH	\$113,801	394.81	\$44,929,947	341.88	\$38,906,436	\$83,836,000

7 **Hydropower Benefits Foregone**

8 The following tables present a summary of the energy, capacity and total hydropower
 9 benefits of the nine alternatives. Benefits are calculated as a difference from a defined
 10 alternative. In this section there are three groupings each with a different baseline
 11 alternative.

- 12 1) All Alternatives with No Action Alternative as baseline
- 13 2) ALT7 Alternatives with ALT7-OptionC as baseline
- 14 3) OptionC Alternatives with the ALT7-OptionC as the baseline

15 **Energy Benefits:**

16 Tables 13, 14, and 15 show the energy benefits calculated to the nearest \$1000.

1
2

**Table 13. Energy Benefits for the ACF River Basin Hydropower System
all alternatives compared to No Action (2015\$)**

Alternatives	Total Energy Value	Energy Benefit Difference from Baseline(No Action)
No Action	\$89,206,000	\$0
ALt1-OptionB	\$90,892,000	\$1,686,000
ALt1-OptionC	\$90,189,000	\$983,000
ALt7-OptionA	\$88,951,000	(\$255,000)
ALt7-OptionB	\$90,745,000	\$1,539,000
Alt7-OptionC	\$90,060,000	\$854,000
ALt7-OptionD	\$88,475,000	(\$731,000)
ALt7-OptionE	\$88,480,000	(\$726,000)
ALt7-OptionF	\$86,157,000	(\$3,049,000)
ALt7-OptionH	\$88,470,000	(\$736,000)

3
4

**Table 14. Energy Benefits for the ACF River Basin Hydropower System
Alt7 Alternatives compared to OptionC (2015 \$)**

Alternatives	Total Energy Value	Energy Benefit Difference from Baseline (Alt7-OptionC)
Alt7-OptionC	\$90,060,000	\$0
ALt7-OptionA	\$88,951,000	(\$1,109,000)
ALt7-OptionB	\$90,745,000	\$685,000
ALt7-OptionD	\$88,475,000	(\$1,585,000)
ALt7-OptionE	\$88,480,000	(\$1,580,000)
ALt7-OptionF	\$86,157,000	(\$3,903,000)
ALt7-OptionH	\$88,470,000	(\$1,590,000)

5
6

**Table 15. Energy Benefits for the ACF River Basin Hydropower System
Option C Alternatives compared to ALT7-OptionC (2015 \$)**

Alternatives	Total Energy Value	Energy Benefit Differenc from Baseline (Alt7-OptionC)
Alt7-OptionC	\$90,060,000	\$0
ALt1-OptionC	\$90,189,000	\$129,000

1 **Capacity Benefits:**

2 Tables 16, 17, and 18 show the capacity benefits calculated to the nearest \$1000.

3 **Table 16. Capacity Benefits for the ACF River Basin Hydropower System**
 4 **all Alternatives compared to No Action (2015 \$)**

	Total Capacity Value \$ (rounded to nearest 1000)	Capacity Benefit Difference from Baseline(No Action)
No Action	\$83,976,000	\$0
ALt1-OptionB	\$83,552,000	(\$424,000)
ALt1-OptionC	\$84,278,000	\$302,000
ALt7-OptionA	\$83,787,000	(\$189,000)
ALt7-OptionB	\$83,155,000	(\$821,000)
Alt7-OptionC	\$84,248,000	\$272,000
ALt7-OptionD	\$83,876,000	(\$100,000)
ALt7-OptionE	\$83,833,000	(\$143,000)
ALt7-OptionF	\$83,298,000	(\$678,000)
ALt7-OptionH	\$83,836,000	(\$140,000)

5 **Table 17. Capacity Benefits for the ACF River Basin Hydropower System**
 6 **Alt7 Alternatives compared to OptionC (2015 \$)**

	Total Capacity Value \$ (rounded to nearest 1000)	Capacity Benefit Difference from Baseline (Alt7-OptionC)
Alt7-OptionC	\$84,248,000	\$0
ALt7-OptionA	\$83,787,000	(\$461,000)
ALt7-OptionB	\$83,155,000	(\$1,093,000)
ALt7-OptionD	\$83,876,000	(\$372,000)
ALt7-OptionE	\$83,833,000	(\$415,000)
ALt7-OptionF	\$83,298,000	(\$950,000)
ALt7-OptionH	\$83,836,000	(\$412,000)

7 **Table 18. Capacity Benefits for the ACF River Basin Hydropower System**
 8 **Option C Alternatives compared to ALT7-OptionC (2015 \$)**

	Total Capacity Value \$ (rounded to nearest 1000)	Capacity Benefit Difference from Baseline (Alt7-OptionC)
Alt7-OptionC	\$84,248,000	\$0
ALt1-OptionC	\$84,278,000	\$30,000

1 **Total Hydropower Benefits:**

2 Tables 19, 20, and 21 show the total hydropower benefits (capacity and energy)
 3 calculated to the nearest \$1000.

4 **Table 19. Total Hydropower Benefits for the**
 5 **ACF River Basin Hydropower System**
 6 **all Alternatives compared to No Action (2015 \$)**

	Energy Value	Capacity Value	Total Value	Benefits Foregone compared to baseline (No action)
No Action	\$89,206,000	\$83,976,000	\$173,182,000	\$0
ALt1-OptionB	\$90,892,000	\$83,552,000	\$174,444,000	\$1,262,000
ALt1-OptionC	\$90,189,000	\$84,278,000	\$174,467,000	\$1,285,000
ALt7-OptionA	\$88,951,000	\$83,787,000	\$172,738,000	(\$444,000)
ALt7-OptionB	\$90,745,000	\$83,155,000	\$173,900,000	\$718,000
Alt7-OptionC	\$90,060,000	\$84,248,000	\$174,308,000	\$1,126,000
ALt7-OptionD	\$88,475,000	\$83,876,000	\$172,351,000	(\$831,000)
ALt7-OptionE	\$88,480,000	\$83,833,000	\$172,313,000	(\$869,000)
ALt7-OptionF	\$86,157,000	\$83,298,000	\$169,455,000	(\$3,727,000)
ALt7-OptionH	\$88,470,000	\$83,836,000	\$172,306,000	(\$876,000)

7 **Table 20. Total Hydropower Benefits for the**
 8 **ACF River Basin Hydropower System**
 9 **Alt7 Alternatives compared to OptionC (2015 \$)**

	Energy Value	Capacity Value	Total Value	Benefits Foregone compared to baseline (Alt7-OptionC)
Alt7-OptionC	\$90,060,000	\$84,248,000	\$174,308,000	\$0
ALt7-OptionA	\$88,951,000	\$83,787,000	\$172,738,000	(\$1,570,000)
ALt7-OptionB	\$90,745,000	\$83,155,000	\$173,900,000	(\$407,000)
ALt7-OptionD	\$88,475,000	\$83,876,000	\$172,351,000	(\$1,957,000)
ALt7-OptionE	\$88,480,000	\$83,833,000	\$172,314,000	(\$1,994,000)
ALt7-OptionF	\$86,157,000	\$83,298,000	\$169,456,000	(\$4,852,000)
ALt7-OptionH	\$88,470,000	\$83,836,000	\$172,307,000	(\$2,001,000)

1 **Table 21. Total Hydropower Benefits for the ACF River Basin Hydropower System**
 2 **Option C Alternatives compared to ALT7-OptionC (2015 \$)**

	Energy Value	Capacity Value	Total Value	Benefits Foregone compared to baseline (Alt7-OptionC)
Alt7-OptionC	\$90,060,000	\$84,248,000	\$174,308,000	\$0
ALt1-OptionC	\$90,189,000	\$84,278,000	\$174,467,000	\$159,000

3 **FEDERAL BENEFITS:**

4 For some calculations it is necessary to look at the Federal Benefits by themselves.
 5 This section does this for calculating three metrics; Benefits Foregone, Replacement
 6 Cost of Power, and Revenue Foregone. Again these benefits are calculated as a
 7 difference from a defined alternative. In this section we analyze three groupings:

- 8 1) All Alternatives with No Action Alternative as baseline
- 9 2) ALT7 Alternatives with ALT7-OptionC as baseline
- 10 3) OptionC Alternatives with the ALT7-OptionC as the baseline

11 **Benefits Foregone: (Replacement Costs of Power)**

12 Tables 22, 23, and 24 calculates the benefits foregone for the three groupings
 13 described above.

14 **Table 22. Federal Hydropower Value for the ACF River Basin Hydropower System**
 15 **all Alternatives compared to No Action (2015 \$)**

	Energy Value (Federal System)	Capacity Value (Federal System)	Total Value	Benefits Foregone compared to baseline (No Action)
No Action	\$44,643,000	\$45,099,000	\$89,742,000	\$0
ALt1-OptionB	\$45,612,000	\$45,343,000	\$90,955,000	\$1,213,000
ALt1-OptionC	\$45,247,000	\$45,353,000	\$90,600,000	\$858,000
ALt7-OptionA	\$44,532,000	\$44,927,000	\$89,459,000	(\$283,000)
ALt7-OptionB	\$45,540,000	\$45,080,000	\$90,620,000	\$878,000
Alt7-OptionC	\$45,188,000	\$45,286,000	\$90,474,000	\$732,000
ALt7-OptionD	\$44,181,000	\$44,958,000	\$89,139,000	(\$603,000)
ALt7-OptionE	\$44,182,000	\$44,927,000	\$89,109,000	(\$633,000)
ALt7-OptionF	\$42,978,000	\$44,464,000	\$87,442,000	(\$2,300,000)
ALt7-OptionH	\$44,176,000	\$44,930,000	\$89,106,000	(\$636,000)

1 **Table 23. Federal Hydropower Benefits for the ACF River Basin Hydropower System**
 2 **Alt7 Alternatives compared to OptionC (2015 \$)**

Alternative	Total Benefits (Federal System)	Benefits Foregone compared to baseline (Alt7-OptionC)
Alt7-OptionC	\$90,474,000	\$0
ALT7-OptionA	\$89,459,000	(\$1,015,000)
ALT7-OptionB	\$90,955,000	\$481,000
ALT7-OptionD	\$89,139,000	(\$1,335,000)
ALT7-OptionE	\$89,109,000	(\$1,365,000)
ALT7-OptionF	\$87,442,000	(\$3,032,000)
ALT7-OptionH	\$89,106,000	(\$1,368,000)

3 **Table 24. Federal Hydropower Benefits for the ACF River Basin Hydropower System**
 4 **Option C Alternatives compared to ALT7-OptionC (2015 \$)**

Alternative	Total Benefits (Federal System)	Benefits Foregone compared to baseline (Alt7-OptionC)
Alt7-OptionC	\$90,474,000	\$0
ALT1-OptionC	\$90,600,000	\$126,000

5 **Revenue Foregone**

6 SEPA markets its power charging both a capacity rate and an energy rate (Table 25
 7 and 26). The revenue SEPA generates is created from a fixed capacity charge defined
 8 by its marketable capacity explained in Table 1 and the variable annual generation.

9 **Table 25. 1 Capacity and Energy rate as reported in the SEPA 2013 Annual Report for**
 10 **Jim Woodruff and Georgia-Alabama-South Carolina System (GASC) (2013\$)**

System	Capacity Rate	Energy Rate
Jim Woodruff	10.29 \$/kW/Month	26.51 mills/kWh
GASC (Buford, West Point, and Walter F George)	4.81 \$/kW/Month	12.33 mills/kWh

11 **Table 26. Capacity and Energy rate as reported in the SEPA 2013 Annual Report for**
 12 **Jim Woodruff and Georgia-Alabama-South Carolina System (GASC) (2015 \$)**

System	Capacity Rate	Energy Rate
Jim Woodruff	10.59 \$/kW/Month	27.27 mills/kWh
GASC (Buford, West Point, and Walter F George)	4.95 \$/kW/Month	12.69 mills/kWh

1 Using the average annual generation calculated for the Federal plants. Table 27 lists
 2 the estimated energy revenue for all alternatives.

3 **Table 27. Energy Revenues Calculated for all Alternatives**

Alternatives	Average Annual Generation (MWh)		Energy rate (2015) \$/MWh		Estimated Energy Revenue (2015\$)
	GASC (Buford, West Point, and Walter F. George)	Jim Woodruff	GASC	Jim Woodruff	
No Action	770445	254507	\$12.69	\$26.51	\$16,523,928
ALt1-OptionB	793098	254990	\$12.69	\$26.51	\$16,824,199
ALt1-OptionC	784756	254726	\$12.69	\$26.51	\$16,711,340
ALt7-OptionA	769126	254190	\$12.69	\$26.51	\$16,498,786
ALT7-optionB	792636	254740	\$12.69	\$26.51	\$16,811,708
Alt7-OptionC	784316	254504	\$12.69	\$26.51	\$16,699,871
ALt7-OptionD	760658	254406	\$12.69	\$26.51	\$16,397,053
ALt7-OptionE	760696	254412	\$12.69	\$26.51	\$16,397,694
ALt7-OptionF	733152	253524	\$12.69	\$26.51	\$16,024,620
ALt7-OptionH	760567	254405	\$12.69	\$26.51	\$16,395,872

4 Capacity Revenues are based on the estimated changes in dependable capacity as
 5 calculated in Table 7. Table 28 shows the capacity revenues for all alternatives.

6 **Table 28. Capacity Revenue calculated for all Alternatives**

Alternatives	Average Marketable Capacity (KW)		Capacity rate (2015) \$/kW/Month		Estimated Capacity Revenue (2015 \$)
	GASC (Buford, West Point, and Walter F. George)	Jim Woodruff	GASC	Jim Woodruff	
No Action	356710	39590	\$4.81	\$10.59	\$25,620,398
ALt1-OptionB	358770	39660	\$4.81	\$10.59	\$25,748,197
ALt1-OptionC	358930	39600	\$4.81	\$10.59	\$25,749,808
ALt7-OptionA	355230	39550	\$4.81	\$10.59	\$25,529,890
ALT7-optionB	356610	39510	\$4.81	\$10.59	\$25,604,460
Alt7-OptionC	358370	39570	\$4.81	\$10.59	\$25,713,672
ALt7-OptionD	355500	39570	\$4.81	\$10.59	\$25,548,016
ALt7-OptionE	355230	39560	\$4.81	\$10.59	\$25,531,160
ALt7-OptionF	351210	39510	\$4.81	\$10.59	\$25,292,772
ALt7-OptionH	355260	39560	\$4.81	\$10.59	\$25,532,892

1 Table 29 shows the combined capacity and energy revenues for each alternative.

2 **Table 29. Estimated Federal Revenue for all Alternatives (2015 \$)**

Alternatives	Estimated Energy Revenue (2015\$)	Estimated Capacity Revenue (2015\$)	Total Revenue (2015\$)
No Action	\$16,523,928	\$25,620,398	\$40,146,408
ALt1-OptionB	\$16,824,199	\$25,748,197	\$41,076,312
ALt1-OptionC	\$16,711,340	\$25,749,808	\$40,752,524
ALt7-OptionA	\$16,498,786	\$25,529,890	\$38,175,562
ALT7-optionB	\$16,811,708	\$25,604,460	\$40,852,264
Alt7-OptionC	\$16,699,871	\$25,713,672	\$40,819,962
ALt7-OptionD	\$16,397,053	\$25,548,016	\$38,085,786
ALt7-OptionE	\$16,397,694	\$25,531,160	\$38,086,106
ALt7-OptionF	\$16,024,620	\$25,292,772	\$38,168,987
ALt7-OptionH	\$16,395,872	\$25,532,892	\$38,086,252

3 Tables 30 and 31 show the revenue foregone for the two groupings described at the
4 beginning of the section.

5 **Table 30. Revenue Foregone for all Alternatives compared to No Action Alternative**

Alternatives	Estimated Energy Revenue (2015\$)	Estimated Energy Revenue Foregone (2015\$)	Estimated Capacity Revenue (2015\$)	Estimated Capacity Revenue Foregone (2015\$)	Total Revenue Foregone (2015\$)
No Action	\$16,523,928	\$0	\$25,620,398	\$0	\$0
ALt1-OptionB	\$16,824,199	\$300,271	\$25,748,197	\$127,799	\$428,070
ALt1-OptionC	\$16,711,340	\$187,412	\$25,749,808	\$129,409	\$316,821
ALt7-OptionA	\$16,498,786	-\$25,142	\$25,529,890	-\$90,509	-\$115,651
ALT7-optionB	\$16,811,708	\$287,781	\$25,604,460	-\$15,938	\$271,842
Alt7-OptionC	\$16,699,871	\$175,943	\$25,713,672	\$93,274	\$269,217
ALt7-OptionD	\$16,397,053	-\$126,875	\$25,548,016	-\$72,383	-\$199,257
ALt7-OptionE	\$16,397,694	-\$126,233	\$25,531,160	-\$89,238	-\$215,471
ALt7-OptionF	\$16,024,620	-\$499,308	\$25,292,772	-\$327,626	-\$826,934
ALt7-OptionH	\$16,395,872	-\$128,056	\$25,532,892	-\$87,506	-\$215,562

1 **Table 31. Revenue Foregone for Alt7 Alternatives compared to OptionC (2015 \$)**

Alternatives	Estimated Energy Revenue (2015\$)	Estimated Energy Revenue Forgone (2015\$)	Estimated Capacity Revenue (2015\$)	Estimated Capacity Revenue Foregone (2015\$)	Total Revenue Foregone (2015\$)
Alt7-OptionC	\$16,699,871	\$0	\$25,713,672	\$0	\$0
Alt7-OptionA	\$16,498,786	-\$201,085	\$25,529,890	-\$183,782	-\$384,868
ALT7-optionB	\$16,811,708	\$111,837	\$25,604,460	-\$109,212	\$2,625
Alt7-OptionD	\$16,397,053	-\$302,818	\$25,548,016	-\$165,656	-\$468,474
Alt7-OptionE	\$16,397,694	-\$302,177	\$25,531,160	-\$182,512	-\$484,688
Alt7-OptionF	\$16,024,620	-\$675,251	\$25,292,772	-\$420,900	-\$1,096,151
Alt7-OptionH	\$16,395,872	-\$303,999	\$25,532,892	-\$180,780	-\$484,779

2 **Credits to the PMA:**

3 Project costs originally allocated to hydropower are being repaid through power
 4 revenues which are based on rates designed by the Federal power marketing agency
 5 (PMA) to recover allocated costs plus interest within 50 years of the date of commercial
 6 power operation. If a portion of the storage is reallocated from hydropower to water
 7 supply, the PMA's repayment obligation must be reduced in proportion to the lost
 8 energy and marketable capacity.

9 *Planning Guidance Notebook*, Appendix E-57d(3) of ER 1105-2-100 (22 April
 10 2002) states that;

11 "If hydropower revenues are being reduced as a result of the
 12 reallocation, the power marketing agency will be credited for the
 13 amount of revenues to the Treasury foregone as a result of the
 14 reallocation assuming uniform annual repayment."

15 Paragraph d(2)(b) states that;

16 "Revenues foregone to hydropower are the reduction in
 17 revenues accruing to the Treasury as a result of the
 18 reduction in hydropower outputs based on the Baseline rates charged
 19 by the power marketing agency. Revenues foregone from other
 20 project purposes are the reduction in revenues accruing to the
 21 Treasury based on any Baseline repayment agreements."

22 The reduction in revenues for energy and capacity charges presented in Table
 23 31 are used to calculate credits.

24

1 ER 1105-2-100 also allows the marketing agency credit for any additional costs
2 above the lost revenue to recover costs of purchased power to meet the obligations
3 of the current power sales contract(s) relating to the marketing of power from the
4 hydro project(s) where storage is being reallocated. The continuation of Appendix
5 E-57d(3), provides the following guidance:

6 "In instances where Baseline contracts between the power
7 marketing agency and their customer would result in a cost to the
8 Federal Government to acquire replacement power to fulfill the
9 obligations of contracts, an additional credit to the power
10 marketing agency can be made for such costs incurred during the
11 remaining period of the contracts."

12 In both cases the credit in each year will be based on the revenue actually lost or the
13 replacement costs actually incurred (and documented) by the power marketing agency.
14 However, for purposes of providing an estimate of this credit, the cost of replacement
15 power and revenue foregone will be estimated using the procedures described above.

16 **Remaining Period of Contract:**

17 The length of time remaining under the current power sales contracts had to be
18 identified to determine how many years the PMA credit would be based on cost of
19 replacement power. It is understood through conversations with the PMA that contracts
20 are adjusted every five years with the current set of contracts set to expire in 2017. For
21 this estimation for credits to the PMA it is assumed that a contract will be in place
22 extending to 2022.

23 **Credits to the PMA Calculations:**

24 The computation for credits to the PMA is estimated to be the replacement cost of
25 power (benefits foregone) for the ensuing period of contracts, and then the revenue
26 foregone for the remaining 50 years.

27 As shown in Tables 31 and 23 only five of the alternatives show loss in revenue or
28 replacement cost of power. These are ALt7-OptionA, ALt7-OptionD, ALt7-OptionE,
29 ALt7-OptionF, and ALt7-OptionH. Tables 32-36 show the calculations for the estimated
30 credits to the PMA.

Table 32. Estimated Credits to the PMA Alt7-OptionD

Alt7-OptionD				
year	Capacity Revenue Foregone	Energy Revenue Foregone	Replacement Cost of Power	Annual Power Credit
2017			\$1,335,000	\$1,335,000
2018			\$1,336,000	\$1,336,000
2019			\$1,336,000	\$1,336,000
2020			\$1,336,000	\$1,336,000
2021			\$1,336,000	\$1,336,000
2022	\$165,656	\$302,818		\$468,474
2023	\$165,656	\$302,818		\$468,474
2024	\$165,656	\$302,818		\$468,474
2025	\$165,656	\$302,818		\$468,474
2026	\$165,656	\$302,818		\$468,474
2027	\$165,656	\$302,818		\$468,474
2028	\$165,656	\$302,818		\$468,474
2029	\$165,656	\$302,818		\$468,474
2030	\$165,656	\$302,818		\$468,474
2031	\$165,656	\$302,818		\$468,474
2032	\$165,656	\$302,818		\$468,474
2033	\$165,656	\$302,818		\$468,474
2034	\$165,656	\$302,818		\$468,474
2035	\$165,656	\$302,818		\$468,474
2036	\$165,656	\$302,818		\$468,474
2037	\$165,656	\$302,818		\$468,474
2038	\$165,656	\$302,818		\$468,474
2039	\$165,656	\$302,818		\$468,474
2040	\$165,656	\$302,818		\$468,474
2041	\$165,656	\$302,818		\$468,474
2042	\$165,656	\$302,818		\$468,474
2043	\$165,656	\$302,818		\$468,474
2044	\$165,656	\$302,818		\$468,474
2045	\$165,656	\$302,818		\$468,474
2046	\$165,656	\$302,818		\$468,474
2047	\$165,656	\$302,818		\$468,474
2048	\$165,656	\$302,818		\$468,474
2049	\$165,656	\$302,818		\$468,474
2050	\$165,656	\$302,818		\$468,474
2051	\$165,656	\$302,818		\$468,474
2052	\$165,656	\$302,818		\$468,474
2053	\$165,656	\$302,818		\$468,474
2054	\$165,656	\$302,818		\$468,474
2055	\$165,656	\$302,818		\$468,474
2056	\$165,656	\$302,818		\$468,474
2057	\$165,656	\$302,818		\$468,474
2058	\$165,656	\$302,818		\$468,474
2059	\$165,656	\$302,818		\$468,474
2060	\$165,656	\$302,818		\$468,474
2061	\$165,656	\$302,818		\$468,474
2062	\$165,656	\$302,818		\$468,474
2063	\$165,656	\$302,818		\$468,474
2064	\$165,656	\$302,818		\$468,474
2065	\$165,656	\$302,818		\$468,474
2066	\$165,656	\$302,818		\$468,474
			Present Value of Discounted Power Credits	\$13,924,955
			Average Annual PMA Credit	\$648,209

Table 33. Estimated Credits to the PMA Alt7-OptionA

Alt7-OptionA				
year	Capacity Revenue Foregone	Energy Revenue Foregone	Replacement Cost of Power	Annual Power Credit
2017			\$1,015,000	\$1,015,000
2018			\$1,015,000	\$1,015,000
2019			\$1,015,000	\$1,015,000
2020			\$1,015,000	\$1,015,000
2021			\$1,015,000	\$1,015,000
2022	\$183,782	\$201,085		\$384,867
2023	\$183,782	\$201,085		\$384,867
2024	\$183,782	\$201,085		\$384,867
2025	\$183,782	\$201,085		\$384,867
2026	\$183,782	\$201,085		\$384,867
2027	\$183,782	\$201,085		\$384,867
2028	\$183,782	\$201,085		\$384,867
2029	\$183,782	\$201,085		\$384,867
2030	\$183,782	\$201,085		\$384,867
2031	\$183,782	\$201,085		\$384,867
2032	\$183,782	\$201,085		\$384,867
2033	\$183,782	\$201,085		\$384,867
2034	\$183,782	\$201,085		\$384,867
2035	\$183,782	\$201,085		\$384,867
2036	\$183,782	\$201,085		\$384,867
2037	\$183,782	\$201,085		\$384,867
2038	\$183,782	\$201,085		\$384,867
2039	\$183,782	\$201,085		\$384,867
2040	\$183,782	\$201,085		\$384,867
2041	\$183,782	\$201,085		\$384,867
2042	\$183,782	\$201,085		\$384,867
2043	\$183,782	\$201,085		\$384,867
2044	\$183,782	\$201,085		\$384,867
2045	\$183,782	\$201,085		\$384,867
2046	\$183,782	\$201,085		\$384,867
2047	\$183,782	\$201,085		\$384,867
2048	\$183,782	\$201,085		\$384,867
2049	\$183,782	\$201,085		\$384,867
2050	\$183,782	\$201,085		\$384,867
2051	\$183,782	\$201,085		\$384,867
2052	\$183,782	\$201,085		\$384,867
2053	\$183,782	\$201,085		\$384,867
2054	\$183,782	\$201,085		\$384,867
2055	\$183,782	\$201,085		\$384,867
2056	\$183,782	\$201,085		\$384,867
2057	\$183,782	\$201,085		\$384,867
2058	\$183,782	\$201,085		\$384,867
2059	\$183,782	\$201,085		\$384,867
2060	\$183,782	\$201,085		\$384,867
2061	\$183,782	\$201,085		\$384,867
2062	\$183,782	\$201,085		\$384,867
2063	\$183,782	\$201,085		\$384,867
2064	\$183,782	\$201,085		\$384,867
2065	\$183,782	\$201,085		\$384,867
2066	\$183,782	\$201,085		\$384,867
			Present Value of Discounted Power Credits	\$11,073,024
			Average Annual PMA Credit	\$515,451

Table 34. Estimated Credits to the PMA Alt7-OptionE

ALT7-OptionE				
year	Capacity Revenue Foregone	Energy Revenue Foregone	Replacement Cost of Power	Annual Power Credit
2017			\$1,365,000	\$1,365,000
2018			\$1,365,000	\$1,365,000
2019			\$1,365,000	\$1,365,000
2020			\$1,365,000	\$1,365,000
2021			\$1,365,000	\$1,365,000
2022	\$182,512	\$302,177		\$484,689
2023	\$182,512	\$302,177		\$484,689
2024	\$182,512	\$302,177		\$484,689
2025	\$182,512	\$302,177		\$484,689
2026	\$182,512	\$302,177		\$484,689
2027	\$182,512	\$302,177		\$484,689
2028	\$182,512	\$302,177		\$484,689
2029	\$182,512	\$302,177		\$484,689
2030	\$182,512	\$302,177		\$484,689
2031	\$182,512	\$302,177		\$484,689
2032	\$182,512	\$302,177		\$484,689
2033	\$182,512	\$302,177		\$484,689
2034	\$182,512	\$302,177		\$484,689
2035	\$182,512	\$302,177		\$484,689
2036	\$182,512	\$302,177		\$484,689
2037	\$182,512	\$302,177		\$484,689
2038	\$182,512	\$302,177		\$484,689
2039	\$182,512	\$302,177		\$484,689
2040	\$182,512	\$302,177		\$484,689
2041	\$182,512	\$302,177		\$484,689
2042	\$182,512	\$302,177		\$484,689
2043	\$182,512	\$302,177		\$484,689
2044	\$182,512	\$302,177		\$484,689
2045	\$182,512	\$302,177		\$484,689
2046	\$182,512	\$302,177		\$484,689
2047	\$182,512	\$302,177		\$484,689
2048	\$182,512	\$302,177		\$484,689
2049	\$182,512	\$302,177		\$484,689
2050	\$182,512	\$302,177		\$484,689
2051	\$182,512	\$302,177		\$484,689
2052	\$182,512	\$302,177		\$484,689
2053	\$182,512	\$302,177		\$484,689
2054	\$182,512	\$302,177		\$484,689
2055	\$182,512	\$302,177		\$484,689
2056	\$182,512	\$302,177		\$484,689
2057	\$182,512	\$302,177		\$484,689
2058	\$182,512	\$302,177		\$484,689
2059	\$182,512	\$302,177		\$484,689
2060	\$182,512	\$302,177		\$484,689
2061	\$182,512	\$302,177		\$484,689
2062	\$182,512	\$302,177		\$484,689
2063	\$182,512	\$302,177		\$484,689
2064	\$182,512	\$302,177		\$484,689
2065	\$182,512	\$302,177		\$484,689
2066	\$182,512	\$302,177		\$484,689
			Present Value of Discounted Power Credits	\$14,331,167
			Average Annual PMA Credit	\$667,119

Table 35. Estimated Credits to the PMA Alt7-OptionF

ALT7-OptionF				
year	Capacity Revenue Foregone	Energy Revenue Foregone	Replacement Cost of Power	Annual Power Credit
2017			\$3,032,000	\$3,032,000
2018			\$3,032,000	\$3,032,000
2019			\$3,032,000	\$3,032,000
2020			\$3,032,000	\$3,032,000
2021			\$3,032,000	\$3,032,000
2022	\$420,900	\$675,251		\$1,096,151
2023	\$420,900	\$675,251		\$1,096,151
2024	\$420,900	\$675,251		\$1,096,151
2025	\$420,900	\$675,251		\$1,096,151
2026	\$420,900	\$675,251		\$1,096,151
2027	\$420,900	\$675,251		\$1,096,151
2028	\$420,900	\$675,251		\$1,096,151
2029	\$420,900	\$675,251		\$1,096,151
2030	\$420,900	\$675,251		\$1,096,151
2031	\$420,900	\$675,251		\$1,096,151
2032	\$420,900	\$675,251		\$1,096,151
2033	\$420,900	\$675,251		\$1,096,151
2034	\$420,900	\$675,251		\$1,096,151
2035	\$420,900	\$675,251		\$1,096,151
2036	\$420,900	\$675,251		\$1,096,151
2037	\$420,900	\$675,251		\$1,096,151
2038	\$420,900	\$675,251		\$1,096,151
2039	\$420,900	\$675,251		\$1,096,151
2040	\$420,900	\$675,251		\$1,096,151
2041	\$420,900	\$675,251		\$1,096,151
2042	\$420,900	\$675,251		\$1,096,151
2043	\$420,900	\$675,251		\$1,096,151
2044	\$420,900	\$675,251		\$1,096,151
2045	\$420,900	\$675,251		\$1,096,151
2046	\$420,900	\$675,251		\$1,096,151
2047	\$420,900	\$675,251		\$1,096,151
2048	\$420,900	\$675,251		\$1,096,151
2049	\$420,900	\$675,251		\$1,096,151
2050	\$420,900	\$675,251		\$1,096,151
2051	\$420,900	\$675,251		\$1,096,151
2052	\$420,900	\$675,251		\$1,096,151
2053	\$420,900	\$675,251		\$1,096,151
2054	\$420,900	\$675,251		\$1,096,151
2055	\$420,900	\$675,251		\$1,096,151
2056	\$420,900	\$675,251		\$1,096,151
2057	\$420,900	\$675,251		\$1,096,151
2058	\$420,900	\$675,251		\$1,096,151
2059	\$420,900	\$675,251		\$1,096,151
2060	\$420,900	\$675,251		\$1,096,151
2061	\$420,900	\$675,251		\$1,096,151
2062	\$420,900	\$675,251		\$1,096,151
2063	\$420,900	\$675,251		\$1,096,151
2064	\$420,900	\$675,251		\$1,096,151
2065	\$420,900	\$675,251		\$1,096,151
2066	\$420,900	\$675,251		\$1,096,151
			Present Value of Discounted Power Credits	\$32,165,773
			Average Annual PMA Credit	\$1,497,323

Table 36. Estimated Credits to the PMA Alt7-OptionH

ALT7-OptionH				
year	Capacity Revenue Foregone	Energy Revenue Foregone	Replacement Cost of Power	Annual Power Credit
2017			\$1,367,000	\$1,367,000
2018			\$1,367,000	\$1,367,000
2019			\$1,367,000	\$1,367,000
2020			\$1,367,000	\$1,367,000
2021			\$1,367,000	\$1,367,000
2022	\$180,780	\$303,999		\$484,779
2023	\$180,780	\$303,999		\$484,779
2024	\$180,780	\$303,999		\$484,779
2025	\$180,780	\$303,999		\$484,779
2026	\$180,780	\$303,999		\$484,779
2027	\$180,780	\$303,999		\$484,779
2028	\$180,780	\$303,999		\$484,779
2029	\$180,780	\$303,999		\$484,779
2030	\$180,780	\$303,999		\$484,779
2031	\$180,780	\$303,999		\$484,779
2032	\$180,780	\$303,999		\$484,779
2033	\$180,780	\$303,999		\$484,779
2034	\$180,780	\$303,999		\$484,779
2035	\$180,780	\$303,999		\$484,779
2036	\$180,780	\$303,999		\$484,779
2037	\$180,780	\$303,999		\$484,779
2038	\$180,780	\$303,999		\$484,779
2039	\$180,780	\$303,999		\$484,779
2040	\$180,780	\$303,999		\$484,779
2041	\$180,780	\$303,999		\$484,779
2042	\$180,780	\$303,999		\$484,779
2043	\$180,780	\$303,999		\$484,779
2044	\$180,780	\$303,999		\$484,779
2045	\$180,780	\$303,999		\$484,779
2046	\$180,780	\$303,999		\$484,779
2047	\$180,780	\$303,999		\$484,779
2048	\$180,780	\$303,999		\$484,779
2049	\$180,780	\$303,999		\$484,779
2050	\$180,780	\$303,999		\$484,779
2051	\$180,780	\$303,999		\$484,779
2052	\$180,780	\$303,999		\$484,779
2053	\$180,780	\$303,999		\$484,779
2054	\$180,780	\$303,999		\$484,779
2055	\$180,780	\$303,999		\$484,779
2056	\$180,780	\$303,999		\$484,779
2057	\$180,780	\$303,999		\$484,779
2058	\$180,780	\$303,999		\$484,779
2059	\$180,780	\$303,999		\$484,779
2060	\$180,780	\$303,999		\$484,779
2061	\$180,780	\$303,999		\$484,779
2062	\$180,780	\$303,999		\$484,779
2063	\$180,780	\$303,999		\$484,779
2064	\$180,780	\$303,999		\$484,779
2065	\$180,780	\$303,999		\$484,779
2066	\$180,780	\$303,999		\$484,779
			Present Value of Discounted Power Credits	\$14,341,603
			Average Annual PMA Credit	\$667,605

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Appendix C

Pertinent Correspondence

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September 19, 2008

2

Federal Register Vol. 73, No. 183

3

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Method for Controlling Parachute Opening" issued September 2, 2008. This patent has been assigned to the United States Government as represented by the Secretary of the Army.

FOR FURTHER INFORMATION CONTACT: Mr. Jeffrey DiTullio at U.S. Army Soldier Systems Center, Kansas Street, Natick, MA 01760, Phone: (508) 233-4184 or e-mail: Jeffrey.Ditullio@us.army.mil.

SUPPLEMENTARY INFORMATION: Any licenses granted shall comply with 35 U.S.C. 209 and 37 CFR Part 404.

Brenda S. Bowen,

Army Federal Register Liaison Officer.

[FR Doc. E8-21924 Filed 9-18-08; 8:45 am]

BILLING CODE 3710-08-P

DEPARTMENT OF DEFENSE

Department of the Army

Notice of Intent To Prepare an Environmental Impact Statement (EIS) for Disposal and Reuse of Fort Monroe, VA, Resulting From the 2005 Base Closure and Realignment Commission's Recommendations

AGENCY: Department of the Army, DoD.

ACTION: Notice of Availability.

SUMMARY: The Department of the Army intends to prepare an EIS for the disposal and reuse of Fort Monroe, Hampton, Virginia. Pursuant to the BRAC law, Fort Monroe is to close by September 14, 2011. Other actions included in the closing of Fort Monroe are relocating the Headquarters, U.S. Army Training and Doctrine Command (TRADOC); the Installation Management Command (IMCOM) Northeast Region; the U.S. Army Network Enterprise Technology Command (NETCOM) Northeast Region; and the Army Contracting Agency Northeast Region Office to Fort Eustis, Virginia. The U.S. Army Accessions Command and the U.S. Army Cadet Command will be relocated to Fort Knox, Kentucky. These relocations have been or will be addressed in separate National Environmental Policy Act (NEPA) documents for those locations.

DATES: The scoping meeting for the EIS will be held on October 28, 2008, 7 p.m. to 9 p.m., Northampton Community Center, 1435 Todds Lane, Hampton, VA 23666.

FOR FURTHER INFORMATION CONTACT: Ms. Jennifer Guerrero; phone: (757) 788-5363; e-mail: jennifer.lee.guerrero@us.army.mil.

SUPPLEMENTARY INFORMATION: Fort Monroe is a 570-acre U.S. Army

Garrison located at the southeastern tip of the Virginia Lower Peninsula between Hampton Roads and the Lower Chesapeake Bay. The hallmark of Fort Monroe is its stone fortress and moat.

The proposed action (Army primary action) is to dispose of the surplus property generated by the BRAC-mandated closure of Fort Monroe. Reuse of Fort Monroe by others is a secondary action resulting from disposal. The Army has identified two disposal alternatives (early transfer and traditional disposal), a caretaker status alternative, and the no action alternative (as required by NEPA). The EIS will analyze the impact of each reuse alternative upon a wide range of environmental resource areas including, but not limited to, air quality, traffic, noise, biological resources, water resources, geology and soils, cultural resources, socioeconomic, utilities, land use, aesthetics and visual resources, hazardous and toxic substances, and cumulative environmental effects.

The Army will conduct an environmental impact analysis that will focus on the effects of closure and reuse. One preliminary finding is that transportation impacts will have the most significant effect, with or without a major tourism component in the reuse plan. Also, at this early stage, impacts to air quality, infrastructure, and land use are not considered significant. With respect to cultural resources, significant adverse impacts are possible, but these can be mitigated by provisions contained in the Programmatic Agreement between the Army and the Virginia Department of Historic Resources.

Additional resources and conditions may be identified as a result of the scoping process initiated by this NOI. Other opportunities for public participation will be announced in the respective local news media. The public will be invited to participate in scoping activities for the EIS and comments from the public will be considered before any action is taken to implement the disposal and reuse of Fort Monroe.

Dated: September 12, 2008.

Addison D. Davis, IV,

Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health).

[FR Doc. E8-21807 Filed 9-18-08; 8:45 am]

BILLING CODE 3710-08-M

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Public Scoping Meetings for Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Florida, and Alabama

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Supplement to Notice of Intent.

SUMMARY: The U.S. Army Corps of Engineers (Corps), Mobile District, issued a Notice of Intent (NOI) in the **Federal Register** (73 FR 9780) published on February 22, 2008, describing the preparation of a Draft Environmental Impact Statement (EIS), as required by the National Environmental Policy Act (NEPA) to address the proposed update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin located in Georgia, Florida, and Alabama. The Corps will hold five public scoping meetings during the month of October as part of its review and update of the WCM for the ACF River Basin. The public is invited to attend the scoping meetings which will provide information on the WCM update process and afford the opportunity to receive input from the public about their issues and concerns regarding that process. All five public meetings will be held using an open house format, allowing time for participants to review specific information and to provide comments to the resource staff attending the meeting.

DATES: See **SUPPLEMENTARY INFORMATION** section for meeting dates.

ADDRESSES: See **SUPPLEMENTARY INFORMATION** section for meeting addresses.

FOR FURTHER INFORMATION CONTACT:

Questions about the manual update or NEPA process can be answered by: Mr. Brian Zettle, Biologist, Environment and Resources Branch, Planning and Environmental Division, U.S. Army Engineer District-Mobile, Post Office Box 2288, Mobile, AL 36628-0001; Telephone (251) 690-2115; or delivered by electronic facsimile at (251) 694-3815; or e-mail: brian.a.zettle@usace.army.mil. You may also request to be included on the mailing list for public distribution of notices, meeting announcements and documents.

SUPPLEMENTARY INFORMATION: The meeting dates are:

1. October 20, 2008, 5 p.m.-8 p.m. (EDT), Apalachicola, FL.

2. October 21, 2008, 5 p.m.–8 p.m. (CDT), Dothan, AL.
 3. October 22, 2008, 5 p.m.–8 p.m. (EDT), LaGrange, GA.
 4. October 23, 2008, 4 p.m.–7 p.m. (EDT), Marietta, GA.
 5. October 29, 2008, 5 p.m.–8 p.m. (EDT), Gainesville, GA.

The meeting locations are:

1. Apalachicola, FL—Franklin County Courthouse, 33 Market Street, Apalachicola, FL 32320, (850) 653–8861.
 2. Dothan, AL—Dothan Convention Center, 4106 Ross Clark Circle, Dothan, AL 36303, (334) 712–9808.
 3. LaGrange, GA—Callaway Center at West Georgia Technical College, One College Circle, LaGrange, GA 30240, (706) 845–4323.
 4. Marietta, GA—Cobb County Government: Civic Center, Hudgins Hall, 548 S. Marietta Parkway SE., Marietta, GA 30060, (770) 528–8450.
 5. Gainesville, GA—Georgia Mountain Center, 301 Main Street, SW., Gainesville, GA 30503, (770) 534–8420.

Additional information on the ACF River Basin and the Water Control Manual update process will be posted on the Mobile District Web page as it becomes available: <http://www.sam.usace.army.mil>.

Dated: September 12, 2008.

Byron G. Jorns,

Colonel, Corps of Engineers, District Commander.

[FR Doc. E8–21912 Filed 9–18–08; 8:45 am]

BILLING CODE 3710–CR–P

DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

[Docket No. IC08–520–001, FERC–520]

Commission Information Collection Activities, Proposed Collection; Comment Request; Submitted for OMB Review

September 12, 2008.

AGENCY: Federal Energy Regulatory Commission.

ACTION: Notice.

SUMMARY: In compliance with the requirements of section 3507 of the Paperwork Reduction Act of 1995, 44 U.S.C. 3507, the Federal Energy Regulatory Commission (Commission) has submitted the information collection described below to the Office of Management and Budget (OMB) for review of this information collection requirement. Any interested person may file comments directly with OMB and

should address a copy of those comments to the Commission as explained below. The Commission received no comments in response to an earlier **Federal Register** notice of April 15, 2008 (73 FR 20267–20269) and has made this notation in its submission to OMB.

DATES: Comments on the collection of information are due by October 20, 2008.

ADDRESSES: Address comments on the collection of information to the Office of Management and Budget, Office of Information and Regulatory Affairs, Attention: Federal Energy Regulatory Commission Desk Officer. Comments to OMB should be filed electronically, *c/o oira_submission@omb.eop.gov* and include the OMB Control No. 1902–0083 as a point of reference. The Desk Officer may be reached by telephone at 202–395–7345. A copy of the comments should also be sent to the Federal Energy Regulatory Commission, Office of the Executive Director, ED–34, Attention: Michael Miller, 888 First Street, NE., Washington, DC 20426. Comments may be filed either in paper format or electronically. Those persons filing electronically do not need to make a paper filing. For paper filings, such comments should be submitted to the Secretary of the Commission, Federal Energy Regulatory Commission, 888 First Street, NE., Washington, DC 20426 and should refer to Docket No. IC08–520–001. Documents filed electronically via the Internet must be prepared in an acceptable filing format and in compliance with the Federal Energy Regulatory Commission submission guidelines. Complete filing instructions and acceptable filing formats are available at (<http://www.ferc.gov/help/submission-guide/electronic-media.asp>). To file the document electronically, access the Commission's Web site and click on Documents & Filing, E-Filing (<http://www.ferc.gov/docs-filing/efiling.asp>), and then follow the instructions for each screen. First time users will have to establish a user name and password. The Commission will send an automatic acknowledgement to the sender's e-mail address upon receipt of comments.

All comments may be viewed, printed or downloaded remotely via the Internet through FERC's homepage using the "eLibrary" link. For user assistance, contact ferconlinesupport@ferc.gov or toll-free at (866) 208–3676 or for TTY, contact (202) 502–8659.

FOR FURTHER INFORMATION CONTACT:

Michael Miller may be reached by telephone at (202) 502–8415, by fax at

(202) 273–0873, and by e-mail at michael.miller@ferc.gov.

SUPPLEMENTARY INFORMATION: The information collected under the requirements of FERC–520 "Application for Authority to Hold Interlocking Directorate Positions" (OMB No. 1902–0083) is used by the Commission to implement the statutory provisions of section 305 of the Federal Power Act (FPA) as amended by Title II, section 211 of the Public Utility Regulatory Policies Act of 1978 (PURPA)(16 U.S.C. 825d). Section 305(b) makes the holding of certain defined interlocking corporate positions unlawful unless the Commission has authorized the interlocks to be held and, requires the applicant to show in a form and manner as prescribed by the Commission, that neither public nor private interests will be adversely affected by the holding of the position. The Commission implements these provisions through its filing requirements in the Code of Federal Regulations (CFR) 18 CFR part 45. The information required under Part 45 generally identifies the applicant, describes the various interlocking positions the applicant seeks authorization to hold, provides information on the applicant's financial interests, other officers and directors of the firms involved, and the nature of the business relationships among the firms.

Two types of FERC–520 applications are provided for, that which is described in 18 CFR 45.8 as a "full" application and that which is described in 18 CFR 45.9 as an "informal" application for automatic authorization. Section 45.8 "full" applications are made by (1) an officer or director of more than one public utility; (2) an officer or director of a public utility and of a public utility securities underwriter; or (3) an officer or director of a public utility and of an electrical equipment supplier to that utility. Section 45.9 "informational applications" are made by (1) an officer or director of two or more public utilities where the same holding company owns, directly or indirectly, wholly or in part, the other public utility; (2) an officer or director of two public utilities, if one utility is owned, wholly or in part, by the other; or (3) an officer or director of more than one public utility, if such person is already authorized under Part 45 to hold different positions where the interlock involves affiliated public utilities.

Without this information collection, the Commission and the public would not be able to inquire into and determine whether public or private interests will be adversely affected by the holding of such positions.

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November 19, 2009

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The clause at DFARS 252.228–7005, Accident Reporting and Investigation Involving Aircraft, Missiles, and Space Launch Vehicles, requires the contractor to report promptly to the administrative contracting officer all pertinent facts relating to each accident involving an aircraft, missile, or space launch vehicle being manufactured, modified, repaired, or overhauled in connection with the contract.

The clause at DFARS 252.228–7006, Compliance with Spanish Laws and Insurance, requires the contractor to provide the contracting officer with a written representation that the contractor has obtained the required types of insurance in the minimum amounts specified in the clause, when performing a service or construction contract in Spain.

Amy G. Williams,

Editor, Defense Acquisition Regulations System.

[FR Doc. E9–27851 Filed 11–18–09; 8:45 am]

BILLING CODE P

DEPARTMENT OF DEFENSE

Defense Acquisition Regulations System

[OMB Control Number 0704–0434]

Information Collection Requirement; Defense Federal Acquisition Regulation Supplement; Radio Frequency Identification Advance Shipment Notices

AGENCY: Defense Acquisition Regulations System, Department of Defense (DoD).

ACTION: Notice and request for comments regarding a proposed extension of an approved information collection requirement.

SUMMARY: In compliance with Section 3506(c)(2)(A) of the Paperwork Reduction Act of 1995 (44 U.S.C. Chapter 35), DoD announces the proposed extension of a public information collection requirement and seeks public comment on the provisions thereof. DoD invites comments on: (a) Whether the proposed collection of information is necessary for the proper performance of the functions of DoD, including whether the information will have practical utility; (b) the accuracy of the estimate of the burden of the proposed information collection; (c) ways to enhance the quality, utility, and clarity of the information to be collected; and (d) ways to minimize the burden of the information collection on respondents, including the use of

automated collection techniques or other forms of information technology. The Office of Management and Budget (OMB) has approved this information collection for use through December 31, 2009. DoD proposes that OMB approve an extension of the information collection requirement, to expire 3 years after the approval date.

DATES: DoD will consider all comments received by January 19, 2010.

ADDRESSES: You may submit comments identified by OMB Control Number 0704–0434, using any of the following methods:

Federal eRulemaking Portal: <http://www.regulations.gov>. Follow the instructions for submitting comments.

E-mail: dfars@acq.osd.mil. Include OMB Control Number 0704–0434 in the subject line of the message.

Fax: (703) 602–7887.

Mail: Defense Acquisition Regulations System, Attn: Ms. Cassandra R. Freeman, OUSD (AT&L) DPAP (DARS), IMD3D139, 3062 Defense Pentagon, Washington, DC 20301–3062.

Hand Delivery/Courier: Defense Acquisition Regulations System, Crystal Square 4, Suite 200A, 241 18th street, Arlington, VA 22202–3402.

Comments received generally will be posted without change to <http://www.regulations.gov>, including any person information provided.

FOR FURTHER INFORMATION CONTACT: Ms. Cassandra R. Freeman, at (703) 602–8383. The information collection requirement addressed in this notice is available on the World Wide Web at <http://www.acq.osd.mil/dpap/dars/dfars/index.htm>. Paper copies are available from Ms. Cassandra R. Freeman, OUSD (AT&L) DPAP (DARS), IMD3D139, 3062 Defense Pentagon, Washington, DC 20301–3062.

SUPPLEMENTARY INFORMATION:

Title and OMB Number: Defense Federal Acquisition Regulation Supplement (DFARS) Part 211 and related clause at 252.211; Radio Frequency Identification Advance Shipment Notices, OMB Control Number 0704–0434.

Needs and Uses: DoD uses advance shipment notices for the shipment of material containing RFID tag data. DoD receiving personnel use the advance shipment notice to associate the unique identification encoded on the RFID tag with the corresponding shipment. Use of the RFID technology permits DoD an automated and sophisticated end-to-end supply chain, which has increased visibility of assets and permits delivery of supplies to the warfighter more quickly.

Affected Public: Businesses or other for-profit and not-for-profit institutions.
Annual Burden Hours: 31,556.
Number of Respondents: 25,000.
Responses per Respondent: 3,981.
Annual Responses: 101,515,500.
Average Burden per Response: Approximately 1.1 seconds.
Frequency: On Occasion.

Summary of Information Collection

The clause at DFARS 252.211–7006, Radio Frequency Identification Advance Shipment Notices, requires the contractor to ensure that the data on each passive RFID tag are unique and conforms to the requirements that they are readable and affixed to the appropriate location on the specific level of packaging in accordance with MIL–STD–129 tag placement specifications. The contractor shall encode an approved RFID tag using the appropriate instructions at the time of contract award. Regardless of the selected encoding scheme, the contractor is responsible for ensuring that each tag contains a globally unique identifier. The contractor shall electronically submit advance shipment notices with the RFID tag identification in advance of the shipment in accordance with the procedures at http://www.acq.osd.mil/log/rfid/advance_shipment_ntc.htm.

Amy G. Williams,

Editor, Defense Acquisition Regulations System.

[FR Doc. E9–27853 Filed 11–18–09; 8:45 am]

BILLING CODE P

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Notice of Intent To Revise Scope of Draft Environmental Impact Statement for Updating the Water Control Manuals for the Apalachicola-Chattahoochee-Flint River Basin To Account for Federal District Court Ruling

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: Notice is hereby given that the U.S. Army Corps of Engineers (Corps), Mobile District, intends to revise the scope of the Environmental Impact Statement (EIS) for the Water Control Manuals updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Alabama, Florida, and Georgia, to account for a July 17, 2009 Federal court ruling. On July 17,

2009, Judge Paul A. Magnuson issued a memorandum and order in the case *In re Tri-State Water Rights Litigation* (M.D. Fla. No. 3:07-md-01), addressing the Corps' authority to provide water supply benefits through its operation of the Buford Dam/Lake Sidney Lanier project. The Corps solicits comments from interested persons regarding significant new information and circumstances introduced by the July 17, 2009, Order related to the scope of the EIS in connection with the water control manual updates. Public comments will be considered in preparation of the Draft EIS and updated water control manuals.

A Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) was published in the **Federal Register** (73 FR 9780) on February 22, 2008. In January 2009, after considering public comments, the Corps published a Final Scoping Report, Environmental Impact Statement, Update of the Apalachicola-Chattahoochee-Flint (ACF) River Basin, in Alabama, Florida, and Georgia, available at <http://www.sam.usace.army.mil/pa/acf-wcm/>. Any comments previously submitted will be reviewed and addressed in any scoping revisions. There is no need to resubmit comments previously provided during the 2008 scoping effort, unless in your opinion the above-cited district court decision necessitates additional comments from you.

DATES: The public comment period will commence with publication of this notice, and will end 45 days after its publication. This notice will also be distributed to those who commented during the original scoping period of October-December 2008. This distribution will occur by mail and/or e-mail on or about the date of this notice. No additional public scoping meetings are planned. Comments on the scope of the EIS, including concerns, issues, or proposed alternatives that should be considered in the EIS, should be submitted in writing to (see **ADDRESSES**) and will be accepted throughout the public comment period. Comments may also be submitted by using the electronic comment form at: http://www.sam.usace.army.mil/pa/acf-wcm/mail_list.htm#form.

ADDRESSES: To facilitate the Master Water Control Manual update, a support contract has been awarded to Tetra Tech, Inc. for preparation of the EIS and additional scoping. Please mail written comments to Tetra Tech, Inc., 107 Saint Francis Street, Ste. 1403, Mobile, AL 36602-9986.

FOR FURTHER INFORMATION CONTACT: Questions about the manual update or

National Environmental Policy Act (NEPA) process should be directed to: Mr. Brian Zettle, Biologist, Environment and Resources Branch, Planning and Environmental Division, U.S. Army Engineer District-Mobile, Post Office Box 2288, Mobile, AL 36628-0001; Telephone (251) 690-2115; or delivered by electronic facsimile at (251) 694-3815; or e-mail: brian.a.zettle@usace.army.mil. You may also request to be included on the mailing list for public distribution of notices, meeting announcements and documents.

SUPPLEMENTARY INFORMATION: The Corps is updating the water control plans and manuals for the ACF Basin. This effort will include an updated Master Water Control Manual, containing plans for the coordinated operation of the five Federal reservoirs within the ACF basin as a system, and updated Water Control Manuals for each of those reservoirs, containing plans for the operation of those projects for their authorized purposes. Collectively, these documents may be referred to as the "water control plans and manuals," "water control manuals," or simply as the "Master Water Control Manual," which includes the project-specific water control manuals. The water control plans and manuals will contain drought plans and action zones to assist Federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the Federal reservoirs and how to ensure the safety of dams during atypical conditions such as droughts and floods. The draft EIS will assess environmental impacts associated with these updated operating criteria and guidelines.

On July 17, 2009, Judge Paul A. Magnuson issued a memorandum and order in the *Tri-State Water Rights Litigation* available at http://www.sam.usace.army.mil/pa/acf-wcm/pdf/071709court_ruling.PDF. The court's ruling has introduced new information and circumstances that bear upon certain determinations reflected in the Corps' January 2009 Final Scoping Report, to the extent that those determinations included operating the Lake Lanier/Buford Dam project to support present or increased levels of municipal and industrial water supply withdrawals.

The court determined that the Corps has exceeded its authority under the project authorization and the Water Supply Act of 1958 by operating the Buford Dam/Lake Lanier project to accommodate present levels of withdrawals for water supply. The court's order states that "absent

Congressional authorization or some other resolution of this dispute" within three years of July 17, 2009, "the operation of Buford Dam will return to the 'baseline' operation of the mid-1970s. Thus, the required off-peak flow will be 600 cfs [cubic feet per second] and only Gainesville and Buford will be allowed to withdraw water from the lake." The order states that until that time, "the parties may continue to operate at current water-supply withdrawal levels but should not increase those withdrawals absent the agreement of all other parties to this matter."

As a result of this ruling, the Corps is revising the scope of the EIS and water control manual updates in the following respects:

a. In updating the ACF water control plans and manuals, which are expected to be implemented in approximately three years, i.e., in July 2012, the Corps will consider only operations that are within existing authority. The Corps previously announced its intent to update the plans and manuals "to reflect current operations." Because the court has held that the Corps lacks authority to continue to support present levels of water supply withdrawals at Lake Lanier or to reallocate storage to accommodate those or additional withdrawals, and because the court has ordered that most withdrawals from Lake Lanier must cease in 2012, the Corps will update the plans and manuals for operating the Lake Lanier project in a manner that reflects the court's order. Thus, the Corps will not continue to accommodate the present level of withdrawals beyond July 2012, nor will the Corps consider a reallocation of storage for water supply at Lake Lanier as part of the process for updating the ACF water control plans and manuals. Should the States and other interested parties to *In re Tri-State Water Rights Litigation* reach an agreement that involves reallocation of storage for water supply, the Corps would be prepared to submit that agreement to the Army and higher Executive Branch authorities for consideration and possible referral to Congress. Should Congress enact legislation authorizing additional water supply at Lake Lanier, the Corps would update its operations, plans and manuals accordingly.

b. Pursuant to the court's order, as of July 17, 2012, the updated manuals will reflect that water supply withdrawals from Lake Lanier will be limited to the amounts authorized by relocation agreements with the Cities of Gainesville and Buford, Georgia. Those agreements, which were executed at the

time of the reservoir's construction, authorize withdrawals of 8 million gallons per day (mgd) for Gainesville and 2 mgd for Buford, a combined 10 mgd.

c. Pursuant to the court's order, as of July 17, 2012, the updated manuals will reflect that "the required off-peak flow [at Buford Dam] will be 600 cfs." Currently, peak hydropower demand at Buford Dam typically occurs on weekdays from 0500–0900 and 1500–2200 between October 1 and March 31, and on weekdays from 1300–1900 between April 1 and September 30. When the Corps is not generating hydropower to meet this peak demand, the Corps will not release more than 600 cfs from Buford Dam to support water supply withdrawals.

All other aspects described in the notice of intent published in the **Federal Register** (73 FR 9780) on February 22, 2008 remain the same. To satisfy its obligations under NEPA, the Corps will evaluate present circumstances as part of its EIS, while acknowledging that it currently lacks authority to continue to accommodate present levels of water supply at Lake Lanier beyond July 17, 2012.

Additional information on the ACF River Basin and the Master Water Control Manual Update process will be posted on the Mobile District Web page as it becomes available: <http://www.sam.usace.army.mil>.

R. Daren Payne,

*Lieutenant Colonel, Corps of Engineers,
Acting District Commander.*

[FR Doc. E9–27787 Filed 11–18–09; 8:45 am]

BILLING CODE 3720–58–P

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

The Release of the Draft Environmental Impact Statement (DEIS) for the Town of Nags Head Proposed Beach Nourishment Project in Dare County, NC

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice.

SUMMARY: The U.S. Army Corps of Engineers (COE), Wilmington District, Regulatory Division, has received a request for Department of the Army authorization, pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899, from the Town of Nags Head to dredge up to 4.6 million cubic yards of beach-quality sediment from an offshore

borrow source, and deposit the material along approximately 10 miles of ocean shoreline in the Town of Nags Head.

The applicant proposes to utilize a self-contained hopper dredge during a proposed construction window from April through September to undertake the dredging operations and discharge the sand on the beach via submerged pipeline. The applicant's proposed borrow areas include sites identified as having beach quality material in the U.S. Army Corps of Engineers, Wilmington District's EIS, entitled *Final Feasibility Report and Environmental Impact Statement on Hurricane Protection and Beach Erosion Control*, dated September 2000 (USACE 2000).

DATES: Written comments on the Draft EIS will be received until December 30, 2009.

ADDRESSES: Copies of comments and questions regarding the Draft EIS may be addressed to: U.S. Army Corps of Engineers, Wilmington District, Washington Regulatory Field Office. ATTN: File Number 200640282, 2407 W. Fifth Street, Washington, NC 27889. Copies of the Draft EIS can be reviewed on the Wilmington District Regulatory homepage at, <http://www.saw.usace.army.mil/wetlands/regtour.htm>, or contact Ms. Sharon Barnett, at (910) 251–4555, to receive written or CD copies of the Draft EIS.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and DEIS can be directed to Mr. Raleigh Bland, Project Manager, Regulatory Division, telephone: (910) 251–4564.

SUPPLEMENTARY INFORMATION:

1. *Project Description.* The project site is located off NC Highway 12, adjacent to the Atlantic Ocean, in the Town of Nags Head, Dare County, NC. The proposed project totals approximately 10 miles of ocean shoreline beginning approximately 1 mile from the town's northern limit and extending south to the town line adjacent to the Cape Hatteras National Seashore. The proposed borrow area is located in the Atlantic Ocean approximately 2–3 miles offshore of the project site. The Town of Nags Head encompasses approximately 11 miles of ocean shoreline on a barrier island located at the northern end of North Carolina's Outer Banks. The width of the berm of the island's dune system varies considerably with location along the town's beach and with the season. Along most of the project area, the winter berm is non-existent due to continuing erosion processes. Dune habitat is currently decreasing due to excessive erosion of the base or toe of the dunes by waves that travel unimpeded over eroded wet

beach to directly impact dunes. The Town of Nags Head proposes to excavate 4.6 million cubic yards of beach-quality sediment from an offshore borrow source, and deposit the material along approximately 10 miles of ocean shoreline owned by the Town of Nags Head.

2. *Proposed Action.* The purpose of the proposed action is to nourish the Town of Nags Head's ocean shoreline to restore a protective beach, replace sand lost during the period of delay in the implementation of the Federal *Dare County Hurricane Protection and Beach Erosion Control Project* (USACE 2000), and to help preserve property values and the tax base of Dare County.

The proposed borrow area includes portions of offshore areas identified by the Corps of Engineers in the 2000 Federal Dare County Project. The anticipated optimal equipment for excavations will include ocean-certified, self-contained hopper dredges. Such equipment typically excavates shallow trenches (approximately 2–3 foot sections) in each pass (leaving narrow undisturbed areas at the margin of each cut), then travels to a buoyed pipeline anchored close to shore. Discharge to the beach is via submerged pipeline across the surf zone, then by way of shore-based pipe positioned along the dry beach. Only a small area of the Corps borrow area will be required to provide up to 4.6 million cubic yards of beach quality material. The applicant is coordinating the specific area for use in the proposed project with the Corps with the following understanding: (1) The final borrow area required for the emergency beach nourishment project can be limited to the equivalent of a 0.9 square-mile (approximately 575 acres) area, (2) the borrow area used will be contiguous rather than a series of small impact areas, (3) once used, the borrow area will no longer be available for use, consistent with the Dare County Project, and (4) the borrow area will be delineated so as to avoid ongoing biological monitoring stations established by the Corps in connection with the Dare County Project. The project will be built in approximate 1–2 mile sections, optimizing the disposition of pipeline. Sections will be pumped into place with the aid of temporary dikes pushed up by bulldozers in the surf zone. Daily operations will impact approximately 500–1,000 linear feet of shoreline as work progresses in either direction from the submerged pipeline. Upon completion of a section, the submerged pipe and beach-building equipment will be shifted to the next section. As construction progresses, sections will be

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October 12, 2012

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DEPARTMENT OF DEFENSE**Department of the Army; Corps of Engineers****Notice of Intent To Revise Scope of Draft Environmental Impact Statement for Updating the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin To Account for the U.S. Court of Appeals for the Eleventh Circuit Ruling and a June 2012 Legal Opinion of the Corps' Chief Counsel Regarding Authority To Accommodate Municipal and Industrial Water Supply From the Buford Dam/Lake Lanier Project**

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice.

SUMMARY: Notice is hereby given that the U.S. Army Corps of Engineers (Corps), Mobile District, intends to revise the scope of the Environmental Impact Statement (EIS) for the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Alabama, Florida, and Georgia, in light of a June 2011 decision of the U.S. Court of Appeals for the Eleventh Circuit and a June 2012 legal opinion of the Corps' Chief Counsel regarding authority to accommodate municipal and industrial water supply from the Buford Dam/Lake Lanier project. The Corps is updating the water control plans and manuals for the ACF Basin in order to improve operations for authorized purposes to reflect changed conditions since the manuals were last developed. The revised EIS will also consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia has requested from Lake Lanier and downstream at Atlanta. In all other respects, the scope of the EIS for the WCM updates will remain as described in the Updated Scoping Report, Environmental Impact Statement, Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin, in Alabama, Florida, and Georgia (March 2010), available at <http://www.sam.usace.army.mil/pa/acf-wcm/docs.htm>, the Corps solicits comments from interested persons regarding the scope of the EIS for the WCM updates.

DATES: The public comment period will commence with publication of this notice, and will end 60 days after its publication. This notice will also be

distributed to those who commented during the original scoping comment periods of October–December 2008 (see 72 FR 63561 [November 9, 2007], 73 FR 9780 [February 22, 2008], 73 FR 54391 [September 19, 2008]), and November–December 2009 (see 74 FR 59965 [November 19, 2009]). This distribution will occur by mail and/or email on or about the date of this notice. No additional public scoping meetings are planned. Comments on the scope of the EIS, including concerns, issues, or proposed alternatives that should be considered in the EIS, should be submitted in writing to (see **ADDRESSES**) and will be accepted throughout the public comment period. Comments may also be submitted by using the electronic comment form at: <http://www.sam.usace.army.mil/pa/acf-wcm/form.htm>.

ADDRESSES: To facilitate the Master Water Control Manual update, a support contract has been awarded to Tetra Tech, Inc. for preparation of the EIS and additional scoping. Please mail written comments to Tetra Tech, Inc., 61 St. Joseph Street, Suite 550, Mobile, AL 36602–3521.

FOR FURTHER INFORMATION CONTACT: Questions about the manual update or National Environmental Policy Act (NEPA) process should be directed to: Mr. Brian Zettle, Biologist, Environment and Resources Branch, Planning and Environmental Division, U.S. Army Engineer District-Mobile, Post Office Box 2288, Mobile, AL 36628–0001; Telephone (251) 690–2115; or delivered by electronic facsimile at (251) 694–3815; or email: brian.a.zettle@usace.army.mil. You may also request to be included on the mailing list for public distribution of notices, meeting announcements and documents.

SUPPLEMENTARY INFORMATION: The Corps is updating the water control plans and manuals for the ACF Basin in order to improve operations to reflect changed conditions since the manuals were last developed. As explained in a November 2009 **Federal Register** Notice of Intent, 74 FR 59965 (November 19, 2009), and in the March 2010 Updated Scoping Report, the Corps previously narrowed the scope of the EIS for the WCM update to exclude from consideration certain water supply operations at the Buford Dam/Lake Lanier project that would have violated a July 2009 district court order. In June 2011, the U.S. Court of Appeals for the Eleventh Circuit vacated that 2009 district court order and directed the Corps to determine its legal authority to operate the Buford Dam/Lake Lanier Project to accommodate

water supply withdrawals. See *In re Tri-State Water Rights Litigation*, 644 F.3d 1160 (11th Cir. 2011). In compliance with the Eleventh Circuit's order, the Chief Counsel issued a legal opinion on June 25, 2012 (available at http://www.sam.usace.army.mil/2012ACF_legalopinion.pdf), concluding that the Corps has the legal authority to accommodate both current and increased levels of water supply withdrawals from Lake Lanier and downstream at Atlanta. The Chief Counsel's legal opinion does not dictate what operational decisions will be made, with regard to water supply or otherwise, but it does establish certain analytical principles that will be taken into account as the Corps makes its final operational decisions at the conclusion of the WCM update process. Such decisions will be made in light of all applicable authorities, and will be guided by the legal principles articulated in the Chief Counsel's June 25, 2012 opinion.

In light of this legal opinion and the Eleventh Circuit's ruling, it is appropriate for the Corps to consider a broader range of water supply alternatives, including both current levels of water supply withdrawals and increased withdrawals, from Lake Lanier and downstream at Atlanta, that have been determined to be within the Corps' legal authority to implement. All other scoping aspects described in the March 2010 Updated Scoping Report remain the same. Information on the ACF River Basin and the Master Water Control Manual Update process will be posted on the Mobile District Web page as it becomes available: <http://www.sam.usace.army.mil>.

Steven J. Roemhildt,
Colonel, Corps of Engineers, District Commander.

[FR Doc. 2012–25202 Filed 10–11–12; 8:45 am]

BILLING CODE 3720–58–P

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

[Recommendation 2012–2]

Hanford Tank Farms Flammable Gas Safety Strategy

AGENCY: Defense Nuclear Facilities Safety Board.

ACTION: Notice, recommendation.

SUMMARY: Pursuant to 42 U.S.C. 2286a(a)(5), the Defense Nuclear Facilities Safety Board has made a recommendation to the Secretary of Energy concerning the Hanford Tank Farms flammable gas safety strategy.

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Georgia Water Supply Request 2000

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STATE OF GEORGIA
OFFICE OF THE GOVERNOR
ATLANTA 30334-0900

Roy E. Barnes
Governor

May 16, 2000

The Honorable Joseph W. Westphal
Assistant Secretary of the Army for Civil Works
The Pentagon
Room 2E
570 Department of the Army
Washington, D C. 20310

Re: Lake Lanier: Request for Final Agency Action

Dear Secretary Westphal:

I appreciate your taking the time to meet with me in Atlanta on March 7, 2000 to discuss the operation of Lake Lanier to meet the State's water supply needs. In addition, I understand that you had a productive follow-up meeting in Washington, D.C. on April 18, 2000 with representatives of the State.

The purpose of this letter is to request final agency action under 5 U.S.C. § 702 et seq. by the Army Corps of Engineers in the form of a response to the request by the State of Georgia relating to the operation of Lake Lanier. The State of Georgia requests that the Corps manage the resources of Lake Lanier so that water supply needs in Georgia may be met. Specifically, the State requests that the Corps take the following actions:

- Allow municipal and industrial water withdrawals from Lake Lanier to increase as necessary from the 1999 annual average of 131 mgd to the projected 2030 annual average of 297 mgd.
- Release sufficient water from Buford Dam to provide for municipal and industrial water withdrawals from the Chattahoochee River below the dam and upstream of Peachtree Creek to increase as necessary from the 1999 annual average of 278 mgd to the projected 2030 annual average of 408 mgd.
- Provide certainty for these municipal and industrial water withdrawals by entering into long-term contracts with the State of Georgia or municipal and industrial water users.

Secretary Joseph W. Westphal

May 16, 2000

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- Release sufficient water from Buford Dam for environmental quality purposes so that, in addition to meeting the needs described above, there is a minimum instantaneous flow of 750 cfs in the Chattahoochee River just upstream of its confluence with Peachtree Creek in the months of October through May, 850 cfs in the months of June and September, and 950 cfs in the months of July and August, starting in 2001.
- To the extent that hydropower generation at Buford Dam is reduced over time by operating to meet the needs described above and the Corps of Engineers must assess fees from municipal and industrial water users to ensure that the Federal government's project costs are repaid, that the Corps account for return flows, conjunctive use with other project purposes, and separable costs/remaining benefits in calculating such fees, and that the Corps charge such fees only as municipal and industrial water withdrawals increase over time.

The State of Georgia respectfully requests that the Corps take final action on this request as soon as possible.

The enclosed material is submitted in support of the State's request. In addition, we will make available any resources that are necessary to answer any questions that the Corps may have relating to this request. Please do not hesitate to call me with any questions or comments relating to this request or any other aspect of the Corps' operation of Lake Lanier.

Sincerely,

A handwritten signature in black ink, appearing to read "Roy E. Barnes", with a long horizontal flourish extending to the right.

Roy E. Barnes

cc: Brigadier General Richard Capka, Commander
South Atlantic Division Office
U.S. Army Corps of Engineers
60 Forsyth Street
Room 9M15
Atlanta, GA 30303-8801

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Georgia Water Supply Request 2013

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STATE OF GEORGIA
OFFICE OF THE GOVERNOR
ATLANTA 30334-0900

Nathan Deal
GOVERNOR

January 11, 2013

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army for Civil Works
108 Army Pentagon
Washington, D.C. 20310-0108

Re: State of Georgia's Water Supply Request

Dear Secretary Darcy:

On May 16, 2000, Governor Roy Barnes submitted to the Assistant Secretary of the Army for Civil Works a request that the U.S. Army Corps of Engineers allow withdrawals and make releases from Lake Lanier to meet Georgia's projected water supply demands of 705 million gallons per day (mgd). In 2012, after years of litigation, the Corps determined that it has the legal authority to grant Georgia's request. The Corps is now preparing an Environmental Impact Statement and will decide whether and how it will satisfy Georgia's request.

More than 3.3 million Georgians in the Metropolitan Atlanta area now rely on withdrawals or releases from Lake Lanier for water supply. Approximately six million people will rely on Lake Lanier for water supply by the year 2040. Lake Lanier is the most economical and environmentally-protective source of water supply for these Georgians. Operating Lake Lanier as Georgia has requested represents the highest and best use of Lake Lanier. I am confident that the Corps' EIS will concur in this assessment.

To assist the Corps in making its review based on the best and most current information available, I enclose with this letter an Affidavit by Judson H. Turner, Director of the Georgia Environmental Protection Division. Mr. Turner's Affidavit contains updated demographic and water demand data that confirm the continued need for the action Georgia has requested of the Corps, as well as updated analysis of the impact of granting Georgia's request on other project purposes and waters downstream. At a later date, Georgia also will submit an updated analysis of the national economic development benefits of granting Georgia's request.

As reflected in Mr. Turner's affidavit, based on current demographic information and as a consequence of improved water conservation, Georgia now 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. In addition, thanks to improved wastewater treatment, in most



months Georgia requires less flow than previously requested in the Chattahoochee River at the confluence with Peachtree Creek to meet applicable water quality standards.

To provide long-term certainty for all of those involved, Georgia continues to request that the Corps enter into agreements that document the parties' understanding as to how the Corps will operate in support of Georgia's water supply needs. We anticipate that for lake withdrawals that require allocation of storage, certainty will be provided in the form of storage contracts. For river withdrawals, which do not require an allocation of storage, other forms of agreement would be appropriate.

I ask that you act on Georgia's outstanding request at the earliest possible date. If you desire further information from Georgia, please let me know.

Sincerely,

A handwritten signature in black ink that reads "Nathan Deal".

Nathan Deal

cc: Colonel Donald E. Jackson, Commander, South Atlantic Division, U.S. Army Corps of Engineers
Colonel Steven J. Roemhildt, Commander, Mobile District, U.S. Army Corps of Engineers

Affidavit of Judson H. Turner

1. My name is Judson H. Turner. I am Director of the Georgia Environmental Protection Division ("EPD") of the Georgia Department of Natural Resources.
2. In May 2000, the State of Georgia submitted to the Assistant Secretary of the Army for Civil Works a request for reallocation of storage in the Lake Lanier conservation pool to provide sufficient water supplies to meet future municipal and industrial water supply needs of 705 million gallons per day (mgd). In support of that request, Georgia provided an Affidavit from then-EPD Director Harold Reheis discussing Metropolitan Atlanta's then-current and projected water supply needs and why Georgia needed a reallocation of storage in Lake Lanier to meet those needs. Georgia's water supply request remains pending with the Corps. The purpose of this Affidavit is to provide updated data and information that are relevant to that request.
3. The State of Georgia is responsible for managing the quantity and quality of the waters of the State for public and private water supply, and for agricultural, industrial, and recreational uses, while protecting the environment and human health. Georgia law provides that "the government of the state shall assume responsibility for the quality and quantity of such water resources and the establishment and maintenance of a water quality and water quantity control program adequate for present needs and designed to care for the future needs of the state." O.C.G.A. § 12-5-21(a).
4. EPD is the state agency to which state law delegates the responsibility for regulating withdrawals of water from, and discharges of pollutants into, the surface waters of the State. To fulfill this responsibility, EPD maintains data on the population of counties and municipalities within the State, and projections of the State's future population growth and water needs. EPD's expertise in hydrologic and water quality modeling allows it to assess the impact of water withdrawals and wastewater returns. EPD prioritizes water needs and evaluates alternatives for meeting these needs from the State's finite water resources.

GEORGIA'S NEED FOR WATER SUPPLY FROM LAKE LANIER

Current Population and Projections for Future Growth

5. More than 3.3 million Georgians currently rely upon withdrawals of water directly from Lake Lanier or withdrawals of water that the Corps releases from Lake Lanier to the Chattahoochee River to meet their water supply needs. Attached as Appendix 1 is a table that identifies the counties within which municipal and industrial water use customers are dependent in whole or in part on withdrawals and releases from Lake Lanier for their water supply.
6. Also shown in Appendix 1 are projected populations of the counties that will depend on significant amounts of water from Lake Lanier in the future. EPD projects that the number of Georgians who depend upon Lake Lanier for water supply will rise to more than 6 million by around 2040. The numbers in Appendix 1 come from the last published projections of the Georgia Office of Planning and Budget ("OPB"). EPD also reviewed the last published

projections generated by the Metropolitan North Georgia Water Planning District (the "Metro Water District").

7. Municipal water systems in six counties within the Chattahoochee River watershed above the confluence with Peachtree Creek currently withdraw water from the Lake Lanier/Chattahoochee River system. EPD projects that water systems in four additional counties that are riparian or tributary to Lake Lanier will depend upon withdrawals from Lake Lanier in the future. In addition, the following other counties rely on Lake Lanier for water supply: Bartow, Cherokee, Clayton, Douglas, Fayette, Henry, Paulding, Rockdale, and Walton.

8. Counties that rely on Lake Lanier for water supply comprise the majority of the population for the Atlanta Metropolitan Statistical Area ("MSA"), which, according to the U.S. Census Bureau, is the ninth largest MSA by population in the United States. From 2000 to 2010, the Atlanta MSA grew by 24%, a growth rate exceeded by only two other MSA's in the United States. Two counties in the Atlanta MSA (Forsyth and Paulding) were among the 10 fastest growing counties in the United States during this period, both growing at rates greater than 74% for the decade. Gwinnett County added almost 217,000 persons to its population over the decade; for the same period, only 16 counties in the United States added more people.

Municipal and Industrial Water Supply Needs

9. Attached as Appendix 2 and Appendix 3 are the 2011 statistics for water withdrawals by the permit holders who rely upon the Lake Lanier/Chattahoochee River system. The average rate of water withdrawn directly from Lake Lanier in 2011 was 115.2 mgd. *See Appendix 2.* The annual average rate of water withdrawn from the Chattahoochee River between Buford Dam and Peachtree Creek was 245.7 mgd. *See Appendix 3.*

10. Appendix 4 shows projected withdrawals from Lake Lanier and the Chattahoochee River above the confluence with Peachtree Creek for the year 2040. EPD developed its forecasts for future water supply need projections in cooperation with the Metro Water District. These forecasts are based on a number of factors, including population, employment, and commercial and residential consumption rates.

11. EPD and the Metro Water District project that the nine local water systems that currently withdraw water from Lake Lanier or the Chattahoochee River above the confluence with Peachtree Creek will continue to do so. These systems are: City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, City of Cumming, Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta.

12. Of these, five systems – City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, and City of Cumming – withdraw from Lake Lanier. The other four facilities – Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta – withdraw from the Chattahoochee River upstream of the Peachtree Creek confluence. In

addition, EPD projects that Habersham, White, Lumpkin, and Dawson Counties in the future will need to withdraw approximately 41 mgd from Lake Lanier by 2040.

13. The Metro Water District's most recent Water Supply & Conservation Management Plan includes projections for municipal and industrial water supply needs for 2035 and 2050. Based on these projections, adding the 41 mgd of withdrawals by Habersham, White, Lumpkin, and Dawson Counties, and assuming that growth in water usage between 2035 and 2050 will be roughly linear, water supply needs that are dependent on withdrawals and special releases from Lake Lanier will meet or exceed 705 mgd on an annual average basis by 2040. This includes direct withdrawals from Lake Lanier of 297 mgd and withdrawals of 408 mgd from the Chattahoochee River below Buford Dam and above the confluence of the Chattahoochee River and Peachtree Creek.

14. Note that in calculating its water supply projections, the Metro Water District used a population growth rate for the region that is lower than the rate of growth that OPB has projected. Taking into account differing population projections and other variables affecting demand, EPD projects that municipal and industrial water supply demands that are dependent upon withdrawals and special releases from Lake Lanier will reach 705 mgd (including 297 mgd lake withdrawals and 408 mgd river withdrawals) sometime between 2035 and 2045. It is reasonable to plan using the assumption that Georgia's water supply needs will be at least 705 mgd by 2040.

15. In light of Georgia's projections that its water supply needs from Lake Lanier will equal or exceed 705 mgd by 2040, if not a few years sooner, Georgia's request of the Corps is unchanged from what was requested in 2000: that the Corps operate Lanier to accommodate withdrawals of up to 297 mgd annual average from Lake Lanier and 408 mgd annual average from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

16. Georgia plans to help meet demands from Lake Lanier with water that will be stored in the proposed Glades Reservoir upstream of Lake Lanier on Flat Creek, released to Flat Creek, and will flow into Lake Lanier to be withdrawn from one or several of the intakes in Lake Lanier. The Glades Reservoir currently is in the permitting process. Based on reasonable assumptions regarding operation of Glades Reservoir, EPD projects a 30-40 mgd yield from Glades Reservoir. EPD plans to work with the Corps and the reservoir sponsors to ensure that the Glades Reservoir serves as a net benefit to the system yield, provided that the Corps will be able to meet water supply needs of 705 mgd from Lake Lanier. Because the 30-40 mgd released from Glades Reservoir will be withdrawn from Lake Lanier at the same rate that it enters Lake Lanier, no storage should be required for the withdrawal of that water.

Water Conservation

17. The per capita water use rate in the Metropolitan Atlanta Region has fallen in recent years, and the projected demand the region assumes that per capita water use within the region will continue to fall. The use rate is currently 148 gallons per capita per day (gpcd), and is expected to decline to 135 gpcd by the 2035-2040 timeframe. The decline in per capita water use has and is expected to continue to result from implementation of aggressive state and local

water conservation policies, explained in greater detail below. Note that per capita water use and total population are among the factors, but are not the only factors, used to calculate total projected water use in the areas that are to be supplied by withdrawals and releases from Lake Lanier.

18. In 2001, the Georgia General Assembly created the Metro Water District and charged it with developing and maintaining comprehensive long-term plans for water supply and conservation, wastewater management, and watershed management for metro Atlanta. The Metro Water District is comprised of 15 counties, 92 cities, and 56 water supply systems. The plans are implemented by local water systems and local governments and are enforced by the State of Georgia through water permits and through eligibility for grants and loans. The Metro Water District completed development of its initial set of plans in September 2003. The governments within the Metro Water District spent the ensuing five years implementing the plans. In 2009, the Metro Water District adopted the first major update of its plans largely based upon lessons learned during the 2004-2009 implementation period.

19. Water conservation is an important element of the Metro Water District's Water Supply and Water Conservation Plan. The water conservation measures in the Plan are the most aggressive in Georgia and among the most aggressive in the United States. The 2003 Plan, as amended, included ten conservation measures applicable to all water systems and/or local governments. The 2009 update retained all and strengthened three of those measures. The Water Supply and Water Conservation Plan was again amended in December 2010 and added seven measures – two measures applicable throughout the District and five that apply to water systems that withdraw from Lake Lanier or the Chattahoochee River (denoted with asterisk). The water conservation measures in the Metro Water District Plan include: 1) conservation pricing; 2) replace older, inefficient plumbing fixtures; 3) pre-rinse spray valve retrofit education; 4) rain sensor shut-offs on new irrigation systems; 5) sub-unit meters in new multi-family buildings; 6) assess water losses with IWA/AWWA water audit methodology and develop programs to reduce systems water loss; 7) residential water audits; 8) low-flow retrofit kits for residential; 9) commercial water audits; 10) education and public awareness activities; 11) high-efficiency toilets and urinals in government buildings; 12) new car washes to recycle water; 13) expedited water loss reduction*; 14) multi-family HET rebates*; 15) meters with point of use leak detection*; 16) private fire lines to be metered*; 17) maintain a water conservation program*; 18) water waste policy or ordinance; and 19) HET plumbing fixtures in new construction consistent with state legislation.

20. The Metro Water District has made water conservation a priority, and local water systems have shown a strong record of implementation of water conservation measures. In annual progress surveys, the District has found: that tiered water conservation rates are in place throughout the metro area; that water systems serving 96% of the population offer toilet rebates, and over 76,872 older toilets have been replaced since 2008; that the larger systems have implemented programs to reduce system water losses, and, in 2010, over 10,000 leaks were repaired; and 98% of the population of the metro area is targeted with educational and outreach programs by local governments.

21. In 2010, the Georgia Water Stewardship Act was passed by the Georgia General Assembly and signed by Governor Sonny Perdue. For those water users relying on Lake Lanier and the Chattahoochee River above Peachtree Creek, the Water Stewardship Act amplified and supplemented the 19 water conservation policies and programs identified in the Metro Water District's water supply and conservation plan. Among the Act's provisions that supplement the Metro Water District's demand management initiatives are: 1) requiring state government agencies to examine their programs, practices, and rules to identify opportunities to provide for voluntary water conservation; 2) requiring local governments to include water conservation measures in local comprehensive plans; 3) incentives for public water systems to use full cost accounting; and 4) technical assistance to local governments and public water systems for water loss abatement activities.

22. In 2012, EPD conducted an evaluation of the 2000-2010 rates of growth in water demand compared to rates of population growth in the counties with the 15 largest municipal surface water systems in Georgia. Six of the 15 largest municipal surface water systems are located in five counties (i.e., Fulton, DeKalb, Cobb, Gwinnett, and Hall) that rely upon withdrawals or water supply releases from Lake Lanier. The evaluation showed that water use in each of the five counties demonstrated a consistent decreasing trend over the decade, while population in each of those counties increased over the decade. Trends such as these in the five counties and beyond clearly indicate that the water conservation initiatives being implemented in the Atlanta region by the Metro Water District are significantly reducing per capita water demand.

Crediting of Return Flows

23. EPD projects that returns of treated wastewater to Lake Lanier and tributaries immediately upstream of Lake Lanier will mitigate the effect of withdrawals from Lake Lanier. EPD projects that the average annual return of treated wastewater to Lake Lanier and its tributaries in 2040 (assuming withdrawals of 297 mgd) will be approximately 165 mgd. *See* Appendix 4. The net withdrawal from Lake Lanier is therefore expected to be 132 mgd (297 mgd minus 165 mgd).

24. The State of Georgia will allocate the treated wastewater returned to Lake Lanier and its tributaries to particular users of water supply storage in Lake Lanier. This should increase the yield of the storage account or accounts to which the wastewater return is credited rather than count the same as natural inflows, which increase the yield of a water supply storage account only according to the percentage of total conservation storage owned by that user.

25. I am aware of no legal or legitimate policy reason why the Corps should not credit metered return flows to Lake Lanier or its tributaries exclusively to individual water supply storage accounts to which the State of Georgia has allocated such returns.

26. In accordance with federal law, the Corps has long recognized that it is the State, not the Corps, that determines and allocates water rights, and that the Corps should defer to the State's allocation of water rights. Allocation of wastewater return flows to individual users also is a matter of water rights that is best determined by the State.

27. The return of highly-treated wastewater to an existing reservoir increases the yield of that reservoir by reducing the net withdrawals. As a result, return flows keep reservoir levels higher and mitigate the impact of water supply withdrawals. Return flows to a water supply reservoir are a form of water reuse that Georgia's statewide water plan favors.

28. EPD-permitted discharges from wastewater treatment plants are a function of water use and not rainfall and runoff, and therefore are more consistent and reliable than natural inflows. Because they are metered and reported to EPD, wastewater discharges also are easily monitored and accounted for, ensuring that a user would not obtain credit for any returns that do not actually occur.

29. It is more expensive for local wastewater utilities to discharge wastewater to Lake Lanier than to the Chattahoochee River or its tributaries, because they must treat the wastewater to a higher degree to meet applicable water quality standards. To make it worthwhile for these utilities to return wastewater to Lake Lanier, there must be policies in place that incentivize those returns. Therefore, EPD desires to credit to individual water users the exclusive right to withdraw or store the wastewater returns that are made. The Corps should do the same, or should defer to the State's allocation.

30. Thus, consistent with federal law and good policy, in determining the yield of the storage space that is held by or for a water supply user, the Corps should count exclusively to that user's storage space such returns as the State has allocated to that user.

Net Municipal and Industrial Water Consumption

31. A large portion of the metro Atlanta area's treated wastewater is returned to the Chattahoochee River downstream of Buford Dam and upstream of the United States Geological Survey ("USGS") gaging station at Whitesburg, Georgia. In 2011, an annual average of 34.4 mgd of treated wastewater was discharged to the Chattahoochee River between Buford Dam and the Peachtree Creek confluence, and an annual average of 184.2 mgd of treated wastewater was discharged to the Chattahoochee River between the Peachtree Creek confluence and the USGS Whitesburg gage. EPD projects that by 2040 (or as of the date when water withdrawals reach 705 mgd), the amount of treated wastewater discharged to the Chattahoochee River between Buford Dam and the Whitesburg gage will be 385 mgd on an annual basis, including 94 mgd discharged to the reach between Buford Dam and the Peachtree Creek confluence, and 291 mgd to the reach between the Peachtree Creek confluence and the USGS Whitesburg gage. When combined with return flow directly into Lake Lanier, the total return of wastewater associated with the withdrawal of 705 mgd is projected to be 550 mgd, or 78% of the total withdrawal.

32. Therefore, Georgia projects that as of 2040, the total consumptive use from municipal and industrial water supply from Lake Lanier and from the Chattahoochee River above the Whitesburg gage will be approximately 155 mgd, or 239 cfs, on an annual average basis. To put this amount into perspective, it is a mere 1.1% of the 21,587 cfs annual average daily flow of the Apalachicola River just downstream of the Georgia-Florida state line.

In-Stream Demands for Water Quality

33. Metropolitan Atlanta local governments that discharge treated wastewater to the Chattahoochee River also rely upon releases from Lake Lanier to provide consistent flows in the river to assimilate those discharges.

34. EPD has developed a mathematical model, known as the Chattahoochee River Model, to simulate temperature, dissolved oxygen, and the concentrations of individual pollutants (biochemical oxygen demand, organic nitrogen, ammonia, nitrate, organic phosphorus, and ortho phosphate) under different flow, intake, discharge, and meteorological conditions.

35. Based on conditions that existed at the time of Georgia's 2000 water supply request, EPD determined that certain seasonally-varying flows in the Chattahoochee River at the confluence with Peachtree Creek would be needed to meet water quality standards. Thanks to improvements in wastewater treatment since 2000, the Chattahoochee River Model now shows the flows needed to assimilate wastewater in the Chattahoochee River and maintain water quality standards may be reduced.

Why Assurance of Long-Term Supply is Needed Now

36. If Lake Lanier were not available to satisfy the needs included in Georgia's water supply request, additional reservoirs and water resource projects would be needed to replace it. Due to the complexity and uncertainty associated with the permitting processes, planning for the development of new water supply reservoirs must generally begin 15 to 25 years, or even more, before there is a demand for the water.

37. The three major stages of the planning processes are 1) alternatives analysis and source evaluation; 2) detailed engineering and environmental studies; and, 3) state and federal permitting. The first stage includes forecasting future service area population and water demands; evaluating demand management and supply alternatives for meeting the demands; evaluation of source water capacity, quality, and reliability; and development of environmental, historic/archeological, and socio-economic assessments of impacts. In the second stage, detailed engineering and environmental studies must be conducted on the preferred alternatives, and funding sources must be identified and secured. In the third stage, if a new or expanded water supply reservoir is the preferred alternative, the applicant must apply for and secure a Federal Clean Water Act Section 404 permit (issued by the Corps of Engineers), a Clean Water Act Section 401 Water Quality Certification (issued by the State of Georgia), a Safe Dams permit and a water withdrawal permit (both issued by the State of Georgia), and a Safe Drinking Water Act Permit (also issued by the State of Georgia). Before the Corps of Engineers can issue a Section 404 permit, it must comply with provisions of the National Environmental Policy Act (i.e., prepare an Environmental Assessment and possibly an Environmental Impact Statement) and federal regulations. Of all the stages, the Section 404 permitting process generally requires the greatest amount of time and often is followed by legal challenges to the issued permit. As shown in Appendix 6, the process of studying, designing, permitting, financing, and constructing water supply reservoirs in Georgia has required a range of 5 to 25 years to complete, based upon six cases selected for illustration.

38. Georgia desires assurance of storage for direct lake withdrawals through storage contracts. As for water supply releases, the Corps coordinates those with the Atlanta Regional Commission on a weekly basis. According to the 2011 ruling of the United States Court of Appeals for the Eleventh Circuit, the Corps is authorized to provide these releases without reallocating storage to those water supply users downstream. Nevertheless, to assure long-term certainty for all concerned, it is important that the Corps, Georgia, and local governments that Georgia may designate enter into a written agreement documenting their understandings regarding how and when releases for water supply will be coordinated.

Why Lake Lanier Continues to be the Best Alternative

39. As discussed in the Reheis Affidavit, numerous studies dating back to the 1960s have consistently concluded that Lake Lanier and the Chattahoochee River provide the most economical and environmentally-protective alternative for meeting the water supply needs of the region. See Reheis Affidavit at ¶¶ 21-28. As the Reheis Affidavit explains, a number of alternatives were investigated up through 1999, and none of them was determined to be a reasonable alternative. See *id.*

40. As part of the planning process for its 2003 plans and 2009 update, the Metro Water District considered potential water supply source alternatives for the communities in the study area through the planning period. The District's *Water Supply and Water Conservation Management Plan* determined that "after reviewing alternatives to the use of the federal reservoirs, the Metro Water District has concluded that there are no alternatives to the Chattahoochee River and the Etowah River as major water supply sources for north Georgia."

41. A water study task force, comprised of metro Atlanta area government and business leaders and assisted by Boston Consulting Group and technical experts, reached the same conclusion in 2009. The Governor of Georgia convened the task force, known as the Water Contingency Planning Task Force, in response to a decision of the United States District Court that threatened to eliminate virtually all water supply withdrawals and releases from Lake Lanier. The task force studied the costs associated with developing alternative sources of water resources to replace Lake Lanier if the Lake were to cease operating for water supply. The task force concluded that "Lake Lanier is by far the best water supply source for the metro region. If the recommended contingency options were required instead, these options would impose significant incremental costs and environmental impacts the region does not currently face." See *Water Contingency Planning Task Force Findings and Recommendations, 21 December 2009.*

IMPACT OF GEORGIA'S MUNICIPAL AND INDUSTRIAL WATER WITHDRAWAL ON LAKE LANIER AND WATERS DOWNSTREAM

42. EPD has performed computer modeling of the reservoir operations and water withdrawals contemplated in Georgia's water supply request to determine the effects of those operations and withdrawals on Lake Lanier and the Chattahoochee River. EPD's modeling is summarized below and discussed in greater depth in Exhibit A, the Memorandum of Dr. Wei Zeng, manager of EPD's Hydrological Analysis Unit. Although Dr. Zeng, for the purpose of his analysis, assumed that the Corps will continue to operate in accordance with the current version

of the Revised Interim Operation Plan (“RIOP”), the State of Georgia continues to believe that the ACF system can be operated more efficiently for the benefit of all Basin stakeholders and is proposing alternative to the RIOP in our comments on the ACF Water Control Manual EIS Scoping Comments.

Hydropower Production at Lake Lanier and within the ACF System

43. The projected water withdrawals and Corps operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam or the federal reservoirs in the ACF Basin as a whole, and any impact will be gradual over the next several decades. EPD’s modeling indicates that, if viewed in terms of hydropower generation for the federal reservoirs in the ACF Basin as a whole, when Georgia has reached demands of 705 mgd and year 2040 water supply needs are met throughout the rest of Georgia, average annual power generation will be 970,900 MWh, as compared with the 988,055 MWh of (simulated) annual average generation with 2011 water supply levels. Thus, EPD projects a mere 1.7% decrease in hydropower generation basin-wide. *See Zeng Memorandum at Exhibit A.*

44. When Georgia has reached demands of 705 mgd from Lanier and the Chattahoochee River above the Peachtree Creek confluence, and 2040 water supply demands exist throughout the remainder of the basin, the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh, in comparison to the amount of 123,735 MWh under 2011 water use conditions. Thus, the amount of hydropower produced at Lake Lanier with 2040 demands will be only 6% less than the amount being produced with current water supply demands. The effect will be even less in the years before Georgia’s water demand has reached 705 mgd. *See Zeng Memorandum at Exhibit A.*

45. Georgia’s conclusions are consistent with those reached by the Corps in its assessment of the impact to hydropower from granting Georgia’s water supply request as compared with a baseline that assumed virtually no water supply operations at all. Using that baseline of comparison, the Corps concluded that the water supply operations and lake withdrawals would result in less than a 1% reduction to ACF Basin dependable hydropower capacity, and that the lake withdrawals and water supply releases contemplated by Georgia’s water supply request would result in reductions in basinwide hydropower value of 4.4% and less than 1%, respectively. *See Zeng Memorandum at Exhibit A.*

Recreation at Federal Reservoirs

46. The Corps has established three thresholds for assessing impact of reservoir elevation to recreation at Lake Lanier. The first threshold is called Initial Recreation Impact Level (“IIL”), which is the level at which falling reservoir elevation first has some adverse effect on recreation. The Corps has determined that the IIL at Lake Lanier is 1066 feet above mean sea level (msl). The second threshold, the Recreation Impact Level (“RIL”), is the level at which significant impacts to concessions and recreation occurs. The RIL at Lake Lanier is 1063 feet above msl. The third threshold is Water Access Limitation Level (“WAL”), which is the elevation at which more serious impacts to recreation are observed. The WAL at Lake Lanier is 1060 feet above msl.

47. As discussed at greater length in the attached Memorandum of Wei Zeng, under 2007 hydrologic conditions, with existing water supply demands, Lake Lanier is below RIL for 27 days during the primary recreational season in that year (May 1-September 8). EPD's modeling shows that this level of recreation impact will be increased by only 21 days under 2007 hydrologic conditions if Lanier is operated to meet the metro area's 2040 water needs of 705 mgd and Georgia's 2040 water supply needs in the remainder of the basin exist. EPD's modeling also shows that if Lanier is operated to meet Georgia's water supply request, metro area water supply needs from Lake Lanier reach 705 mgd, and 2040 water demands exist elsewhere in the basin, during the recreational season, the elevation of Lake Lanier would be below the ILL for only 5% more of the time, below the RIL for only 8% more of the time, and below the WAL 8% more of the time, than under the baseline condition. See Zeng Memorandum at Exhibit A.

48. At West Point Lake, the Corps has designated a ILL of 632 feet above msl, a RAL of 628 feet above msl, and a WAL of 627 feet above msl. If Lake Lanier is operated to meet water supply needs of 705 mgd, the number of days when West Point Lake falls below the RIL and ILL actually will be lessened, and there will be only a 1% increase in the number of days in which the elevation falls below the WAL.

49. For Lake Walter F. George, the ILL is 187 feet above msl, the RAL is 185 feet above msl, and the WAL is 184 feet above msl. With 2040 water supply demands imposed on the system, Lake Walter F. George will not experience elevations below RIL or WAL, and will see an increase of only 1% to 2% in the number of days below the ILL. See Zeng Memorandum at Exhibit A.

Navigation

50. As the ACF Basin reservoirs, for reasons unrelated to Georgia's water supply usage, are no longer used to support commercial navigation except under rare circumstances, Georgia's water supply request will not impact navigation.

Lake Lanier's Flood Control Function

51. The current request to reallocate the conservation storage to meet Georgia's projected future water supply needs does not involve changing the elevation of the top of conservation pool or the size of the flood control pool. Thus, reallocating part of the conservation storage to accommodate Georgia's increase water will have no impact on the flood control capability of Lake Lanier or the ACF system. Although changes to the size of the flood control pool are not necessary for the Corps to grant Georgia's request, Georgia may still recommend raising the conservation pool, at the appropriate time, if and when it determines that the benefits of doing so exceed any costs.

Impacts on Georgia/Florida State Line Flows

52. EPD's modeling indicates that the net water consumption associated with the municipal and industrial withdrawals contemplated in Georgia's water supply request is projected to have a

minor impact on the flow in the Apalachicola River at the state line. See Zeng Memorandum at Exhibit A.

CONCLUSION

53. The foregoing information affirms and updates Georgia's 2000 request that the Corps operate Lake Lanier to meet water supply needs of 705 mgd annual average gross withdrawal, including 297 mgd annual average gross withdrawal from Lake Lanier and 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence of the Chattahoochee River and Peachtree Creek. Accordingly, the Governor of Georgia has asked that the Corps grant Georgia's request by taking the following actions:

(a) Accommodate water supply demands by providing for 297 mgd annual average gross withdrawal from Lake Lanier and by making releases to allow 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

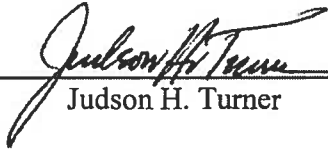
(b) Provide certainty for those municipal and industrial water withdrawals from Lake Lanier that require an allocation of storage by entering into long-term contracts. No storage should be required for withdrawals covered by existing relocation contracts or withdrawals of water released to Lake Lanier from Glades Reservoir upstream. Returns to Lake Lanier or its tributaries of treated wastewater should be credited exclusively to the storage accounts of those whom Georgia EPD designates to receive such credit.

(c) Provide certainty for those municipal and industrial water withdrawals from the Chattahoochee River that rely upon special releases from Lake Lanier by entering into agreements that document the parties' understandings about assurance and coordination of releases.

(d) Release from Lake Lanier enough water to provide a flow in the Chattahoochee River at the confluence with Peachtree Creek as EPD may request to maintain applicable water quality standards.

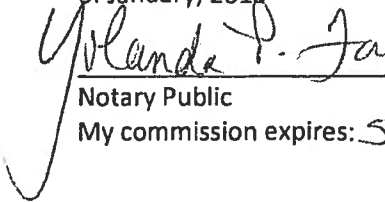
FURTHER AFFIANT SAITH NOT.

This 10th day of January, 2013.



Judson H. Turner

Sworn to and subscribed
before me this 10th day
of January, 2013



Yolanda P. Fanning
Notary Public
My commission expires: Sept 29, 2013



APPENDIX 1

Historical and Forecasted Population of Counties Using Lake Lanier System for Water Supply

County	1990 ¹	2000 ¹	2010 ¹	2020 ²	2030 ²	2040 ³
Cobb	447,745	607,751	688,078	800,469	909,747	1,033,943
Dawson ⁴	9,429	15,999	22,330	27,029	32,022	37,937
DeKalb	545,837	665,865	691,893	761,537	817,276	877,096
Forsyth	44,083	98,407	175,511	256,307	383,258	573,089
Fulton	648,951	816,006	920,581	1,095,897	1,284,954	1,506,626
Gwinnett	352,910	588,448	805,321	1,019,098	1,270,020	1,582,724
Habersham ⁴	27,621	35,902	44,553	48,705	54,623	61,260
Hall	95,428	139,277	179,684	226,172	282,164	352,018
Lumpkin ⁴	14,573	21,016	29,966	38,075	47,960	60,411
White ⁴	13,006	19,944	26,704	31,057	34,841	39,086
Totals ⁵	2,199,583	3,008,615	3,584,621	4,273,267	5,116,865	6,127,000

¹From US Census Bureau

²Georgia Office of Planning and Budget 2012 Projections

³Projection based upon assumption that 2030 – 2040 growth rate (in per cent) will be same as 2020 – 2030.

⁴Watershed counties not currently withdrawing from Lanier, but may withdraw in future.

⁵This total does not include the additional counties that purchase water from the water systems that withdraw water from Lake Lanier and the Chattahoochee River, such as Paulding County.

APPENDIX 2

Water Systems That Withdraw Directly from Lake Lanier

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Annual Average
Forsyth	City of Cumming	17.5	18.8	11.6
Forsyth	Forsyth County	11.8	12.8	8.6
Gwinnett	City of Buford	1.5	1.7	1.3
Gwinnett	Gwinnett County Water & Sewerage Authority	90.9	118.8	76.1
Hall	City of Gainesville	20.7	28.5	17.6
Total				115.2

APPENDIX 3

Water Systems That Rely on Water Supply Releases from Lake Lanier to the Chattahoochee River

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Average Annual
Cobb	Cobb County Marietta Water Authority	51.9	64.8	45.1
DeKalb	DeKalb County Public Works (Water and Sewer)	84.7	114.8	72.7
Fulton	Atlanta – Fulton Water Resources Commission	54.3	69.9	38.7
Fulton	City of Atlanta	101.8	123.4	89.2
Total				245.7

APPENDIX 4

Projected 2040 Water Withdrawals and Returns

(Annual Average)

Table 1 Current and Projected 2040 Water Withdrawals and Returns Above Buford Dam

Time Horizon	Withdrawal (mgd)	Return (mgd)	Net Consumptive Loss (mgd)
2011	120.6 ¹	38.1	82.4
2040	297	165	132

Table 2 Current and Projected 2040 Chattahoochee River Water Withdrawals and Returns

Time Horizon	Withdrawal (mgd) (Buford Dam to Peachtree Creek)	Return (mgd)			Net Consumptive Loss (mgd)
		Atlanta Reach (Buford Dam to Peachtree Creek)	Whitesburg Reach (Peachtree Creek to Whitesburg gage)	Total	
2011	247.5 ²	34.5	185.3	219.8	27.7
2040	408	94	291	385	23

Notes:

¹ Including facilities upstream of Lake Lanier. These additional withdrawals are included to provide the sum of all consumptive loss above Buford Dam.

² Including facilities that withdrew from tributaries of the Chattahoochee River. These additional withdrawals are included to provide the sum of all consumptive loss below Buford Dam and above the Whitesburg gage.

APPENDIX 5

TIME REQUIRED TO PLAN, PERMIT, FINANCE, AND CONSTRUCT WATER SUPPLY RESERVOIRS IN GEORGIA [Note: Try to fit all on one page]

Project Activity	Bear Creek Reservoir, Jackson Co.	Cedar Creek Reservoir, Hall Co.	Tussehaw Creek Reservoir, Butts Co.	Big Haynes Creek Reservoir, Rockdale Co.	Line Creek Reservoir (Lake McIntosh), Fayette Co.	Hickory Log Creek Reservoir, Cherokee Co.
Applicant's initial contact with EPD regarding a new reservoir.	2/2/1994	7/17/1996	9/22/2000	11/5/1987	10/27/1987	3/22/2000
Applicant initial contact with the Corps regarding 404 permit for reservoir.	2/2/1994	2/12/1997	9/22/2000	4/29/1991	1/6/1989	3/22/2000
Applicant submits water withdrawal permit application.	3/3/1997	4/2/2002	3/13/2001	6/21/1999	3/21/2001	10/4/2005
EPD comments on withdrawal application.	5/28/1997	4/22/2002	5/22/2001	12/7/1999	4/16/2001	11/22/2005
EPD provides confirmation of need (to the Corps).	4/20/1995	Information unavailable	11/3/2000	5/6/1991	11/20/2000	11/20/2000
Applicant submits 404 application to the Corps.	2/22/1995	8/26/1997	11/15/2000	5/28/1991	5/1/2002	4/27/2000
The Corps notifies public of the 404 application and requests comments.	5/26/1995	10/8/1997	12/27/2000	11/22/1991	10/3/2002	12/27/2000
The Corps responds to applicant's 404 application.	7/1/1995	11/13/1997	2/1/2001	12/28/1991	11/8/2002	2/28/2001
EPD issues 401 Water Quality Cert.	5/17/1996	8/21/1998	5/22/2001	8/31/1992	9/6/2006	8/2/2002
EPD issues withdrawal permit.	4/1/2002	8/1/2002	2/14/2003	3/22/2002	9/6/2006	9/12/2008
The Corps issues final 404 permit to applicant.	7/20/1996	11/16/1998	10/23/2002	10/2/1992	6/27/2007	5/24/2004
EPD issues Safe Dams permit.	10/1999	10/2001	8/25/2003	5/31/1994	12/9/2009	4/29/2008

Jurisdiction constructs dam.	04/2001	9/11/2003	June 2005	1/27/1997	April 2010	8/5/2005
Jurisdiction fills reservoir.	Spring 2002	8/11/2005	Sept. 2005	June 1998	Started November 1, 2012	6/30/2011

- 1 Exhibit 1 can be found in the Water Supply Storage Assessment Appendix A.

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Appendix D

Summary of Public Scoping Input

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1 The USACE has not developed formal responses to the comments received during scoping but reviewed
2 the comments and suggestions received as categorized in the Scoping Report and developed summaries of
3 the major themes. The major comments and suggestions received during the scoping process are tabled
4 below together with a statement of whether or how the comment or suggestion was eliminated by the
5 screening criteria or whether the comment was considered in updating the WCM. The table defines the
6 major comment categories using a comment identifier (ID) and includes the section in the environmental
7 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 <i>workhorse</i> 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 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. 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 6.7; Section 6.8
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 6.8

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 6.8
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 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 4.3.2.4; 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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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 <i>target</i> flows to more closely match <i>minimum</i> 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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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 6.7; 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.	

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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 6.8
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 6.8; Appendix J

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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;

Number	Scoping Comment	USACE Response/Action	EIS Reference
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.	
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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 <i>critical yield</i> 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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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 6.8
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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 that 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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
HP6	In the EIS, the USACE needs to honor the limitation suggested by a <i>slight decrease</i> 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
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

Number	Scoping Comment	USACE Response/Action	EIS Reference
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
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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

PR-92B

ACF ResSim Modeling in Support of WCM Update and WSSA

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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.

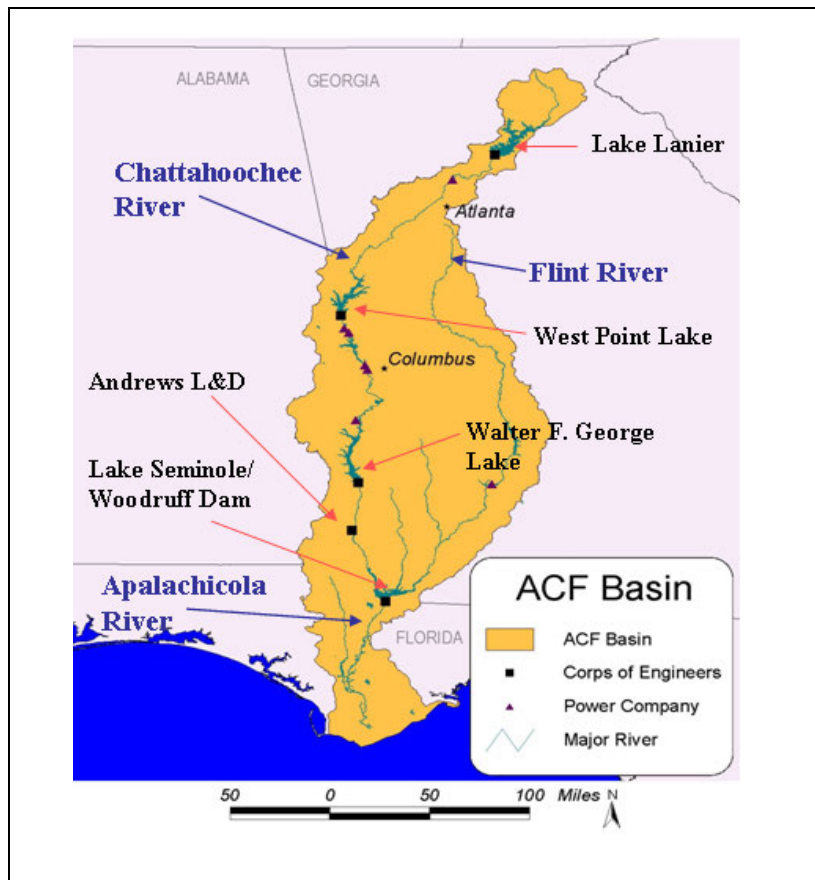


Figure 1. Apalachicola-Chattahoochee-Flint (ACF) River Basin

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

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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.

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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.

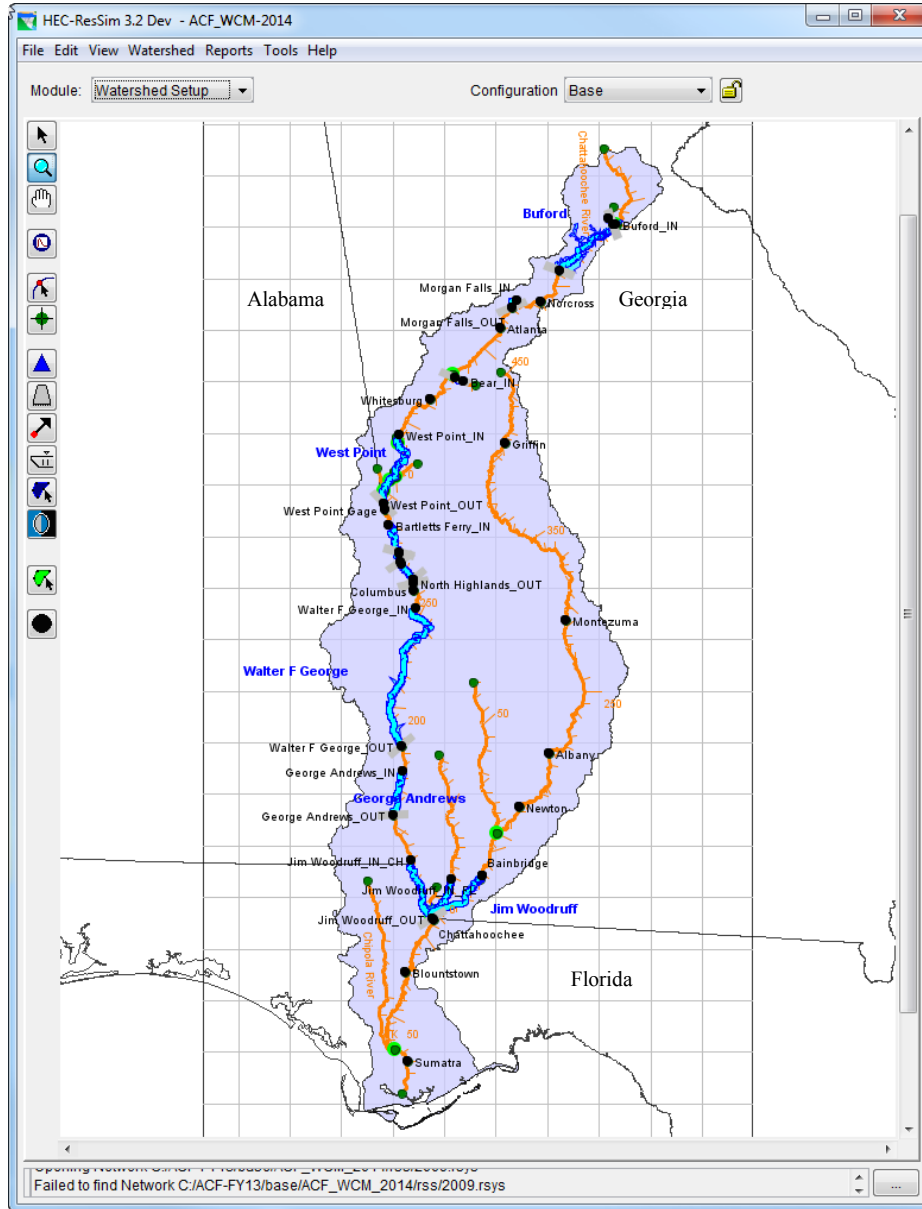


Figure 2. ACF Model – Watershed Setup Module

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).

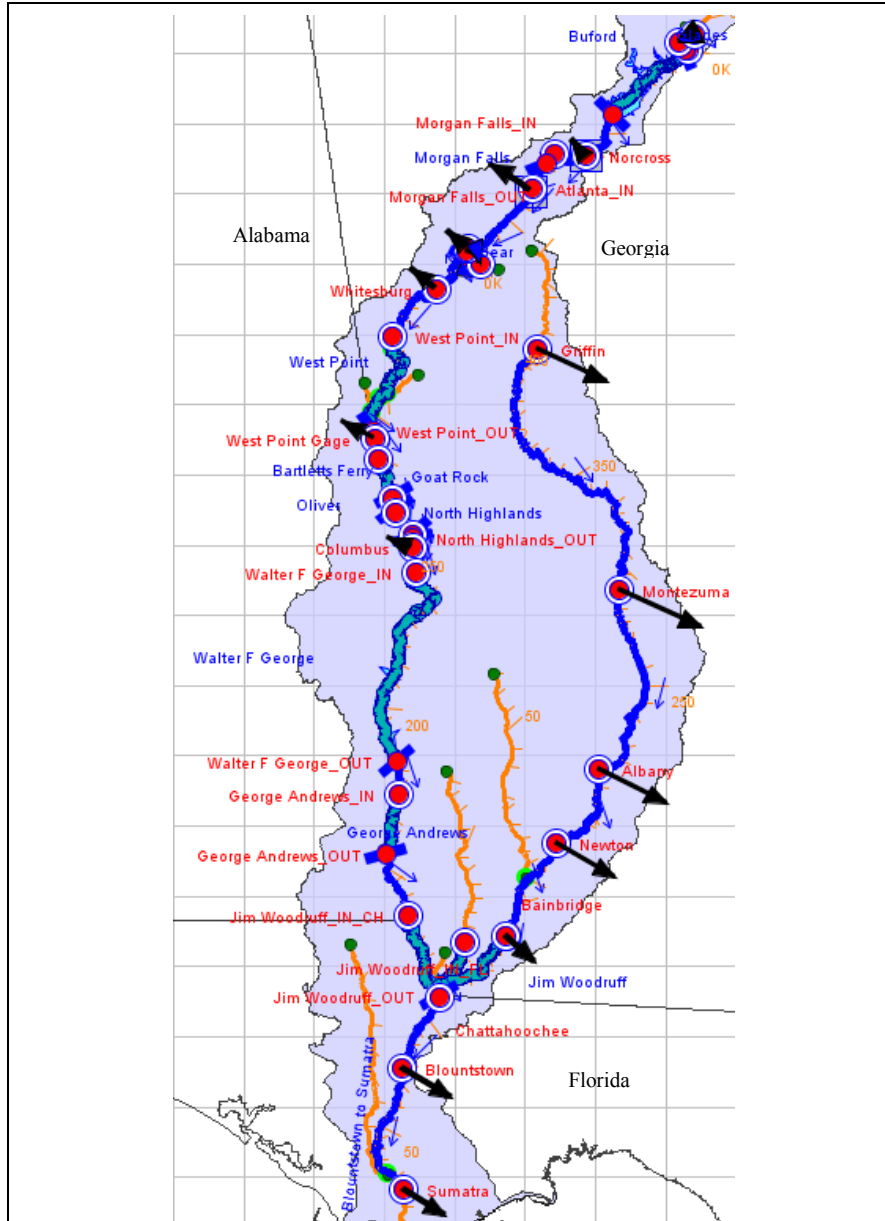


Figure 3. HEC-ResSim Network Schematic – “2014” Network

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 reservoir's 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

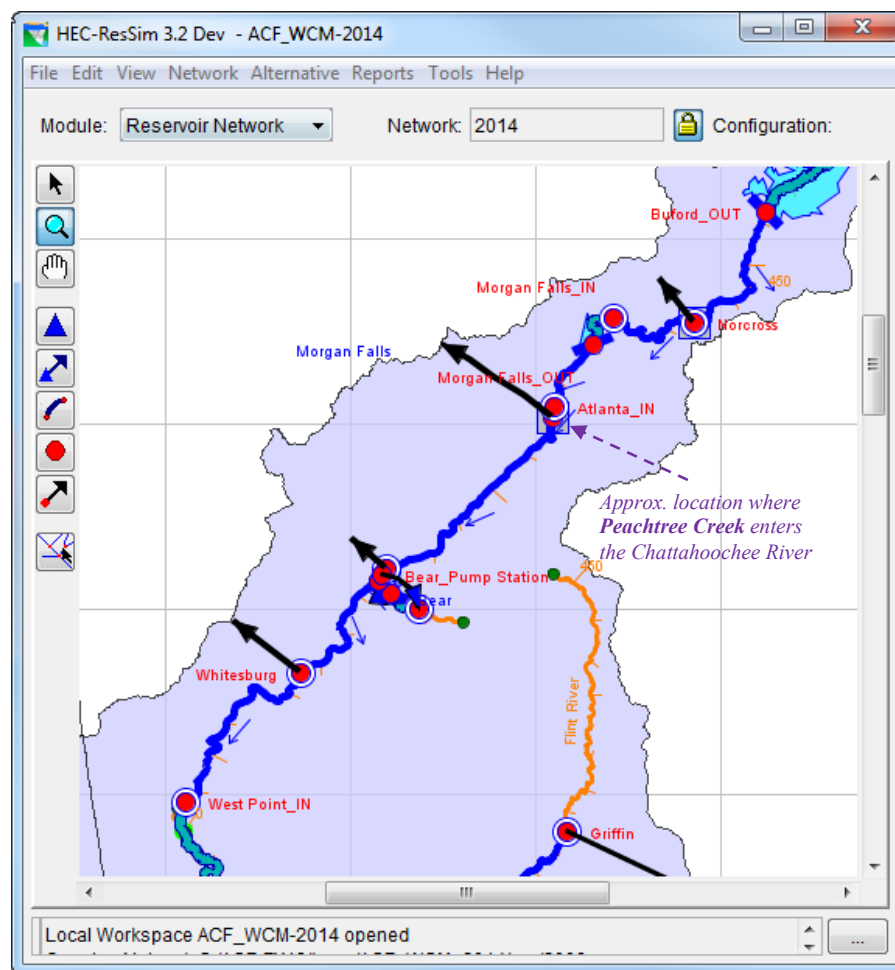


Figure 4. Chattahoochee River between Buford and West Point (“2014” Network)

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 $\frac{3}{4}$ 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 $\frac{1}{4}$ 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.

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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.

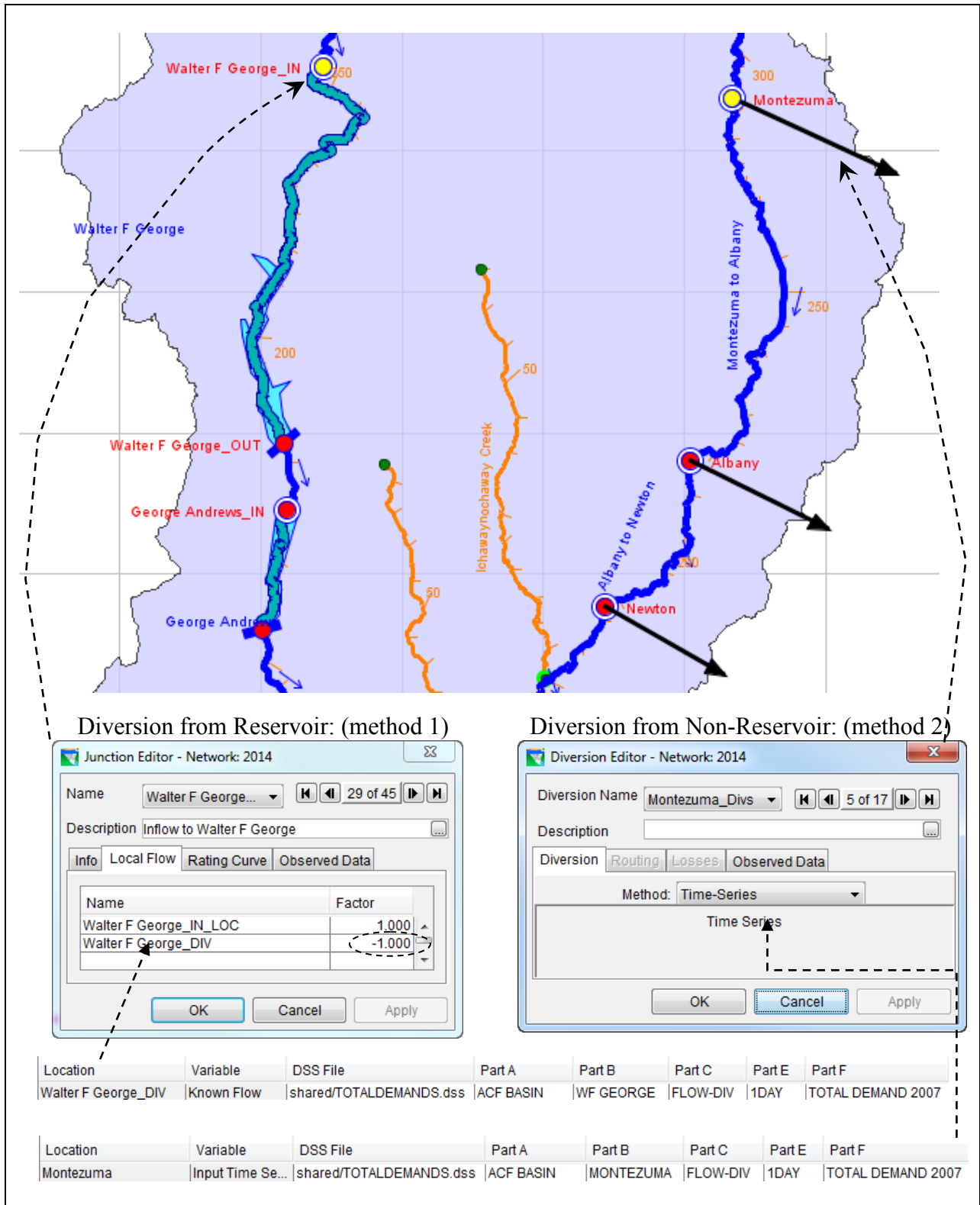


Figure 5. Two Methods Used in Modeling Diversions (for Reservoirs and Non-Reservoirs)

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 as 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.

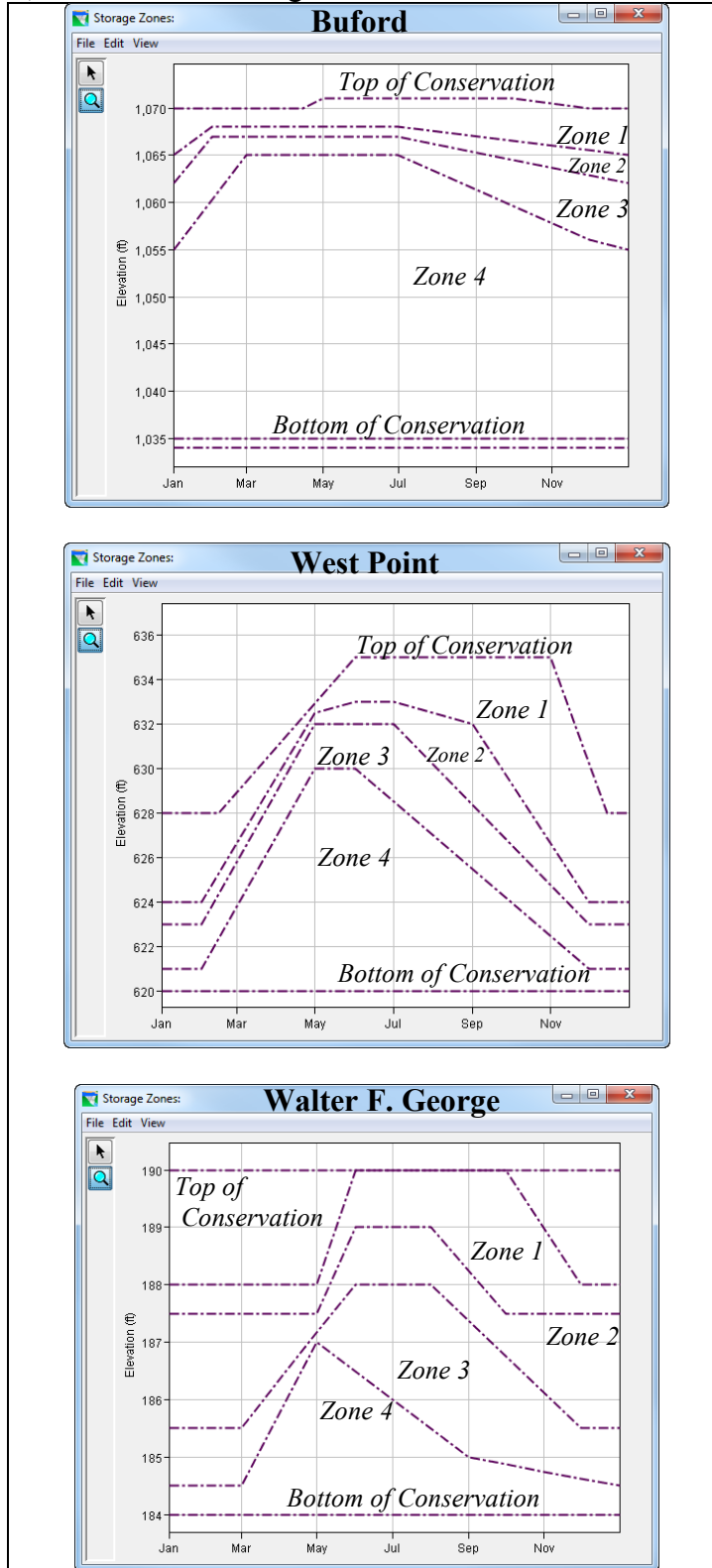


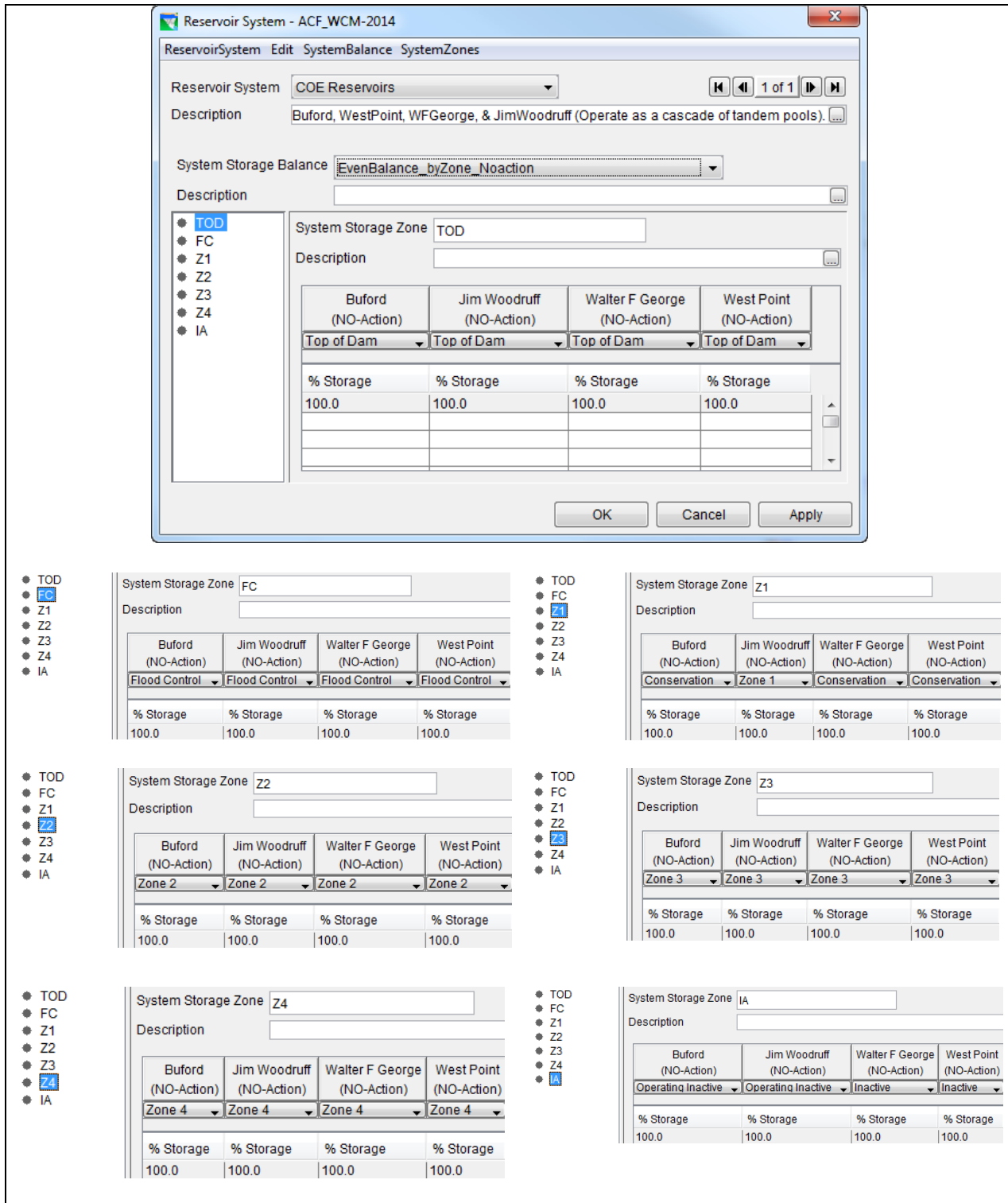
Figure 6. Water Control Action Zones for Buford (Lanier), West Point, and Walter F. George

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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).

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**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.

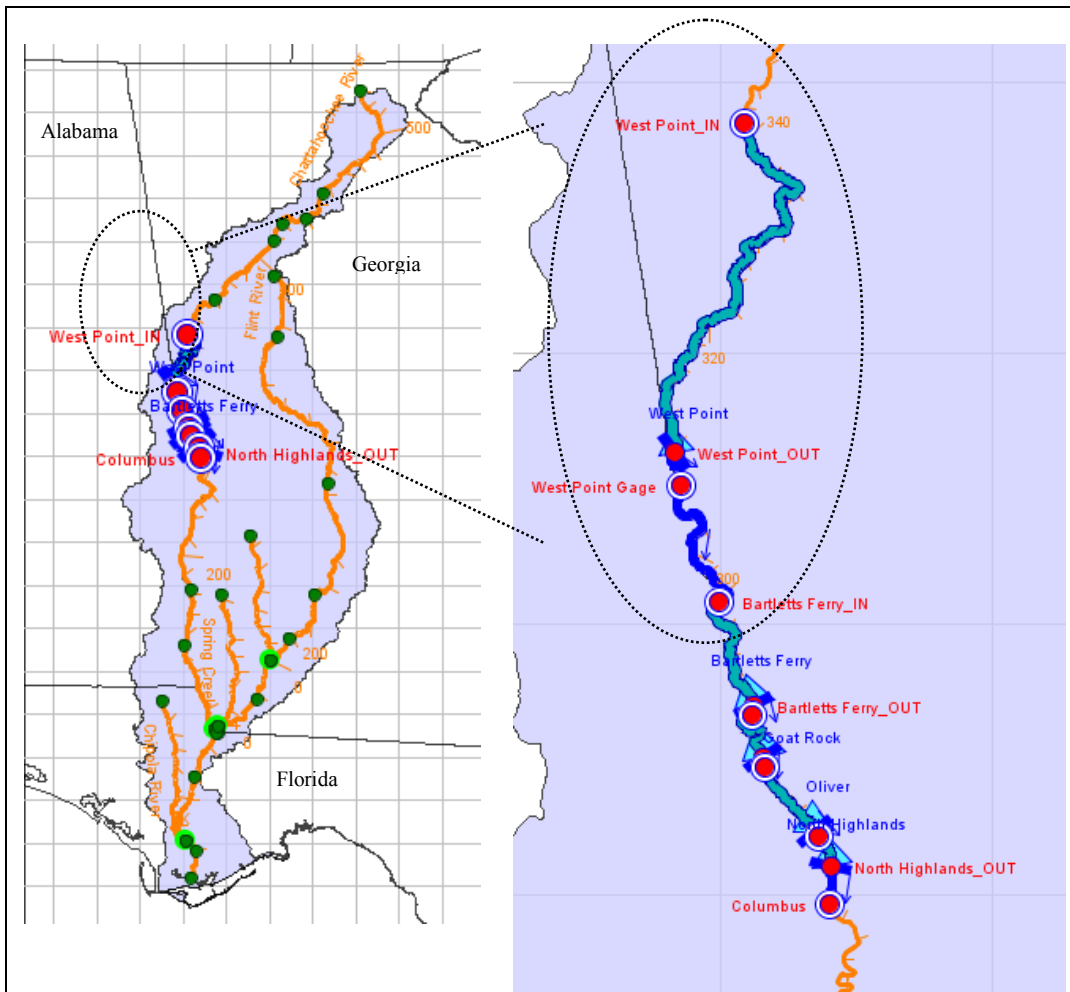


Figure 8. ResSim Network for ACF Flood Modeling (West Point to Columbus)

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.

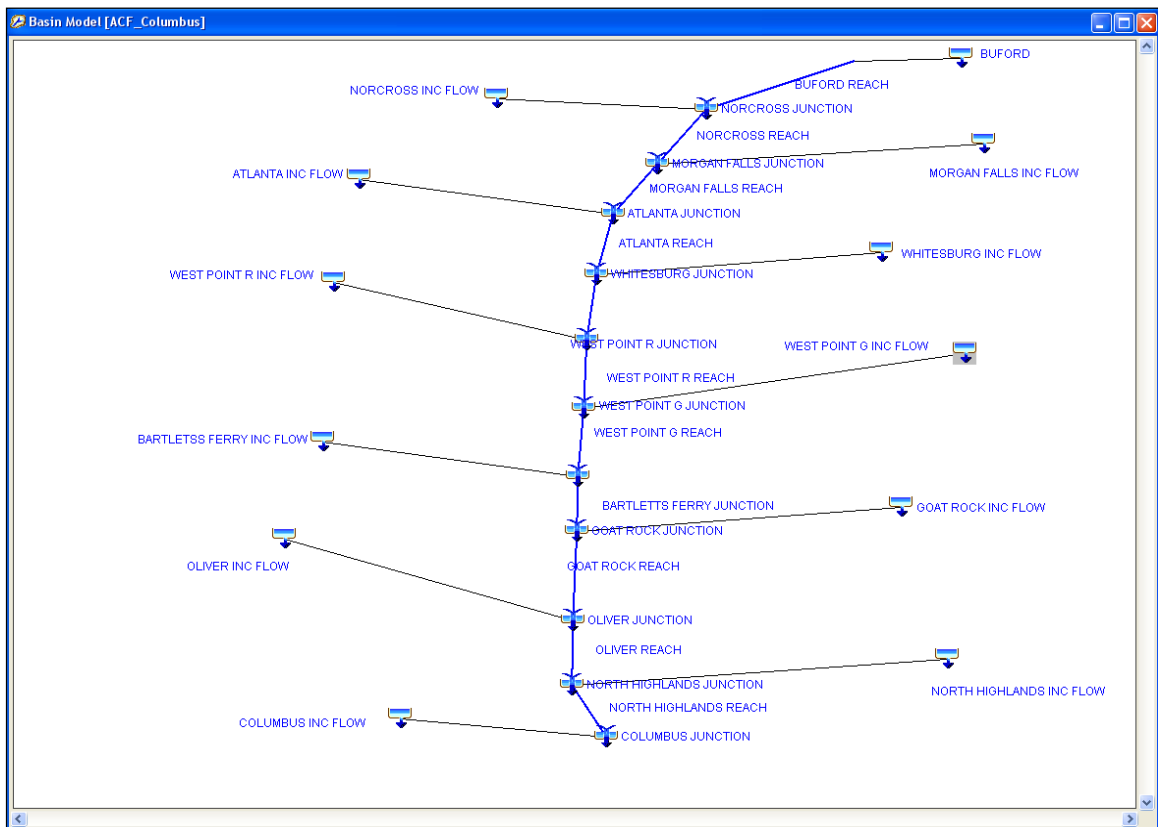


Figure 9. HEC-HMS Schematic for Generating Flood Hydrographs

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

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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.

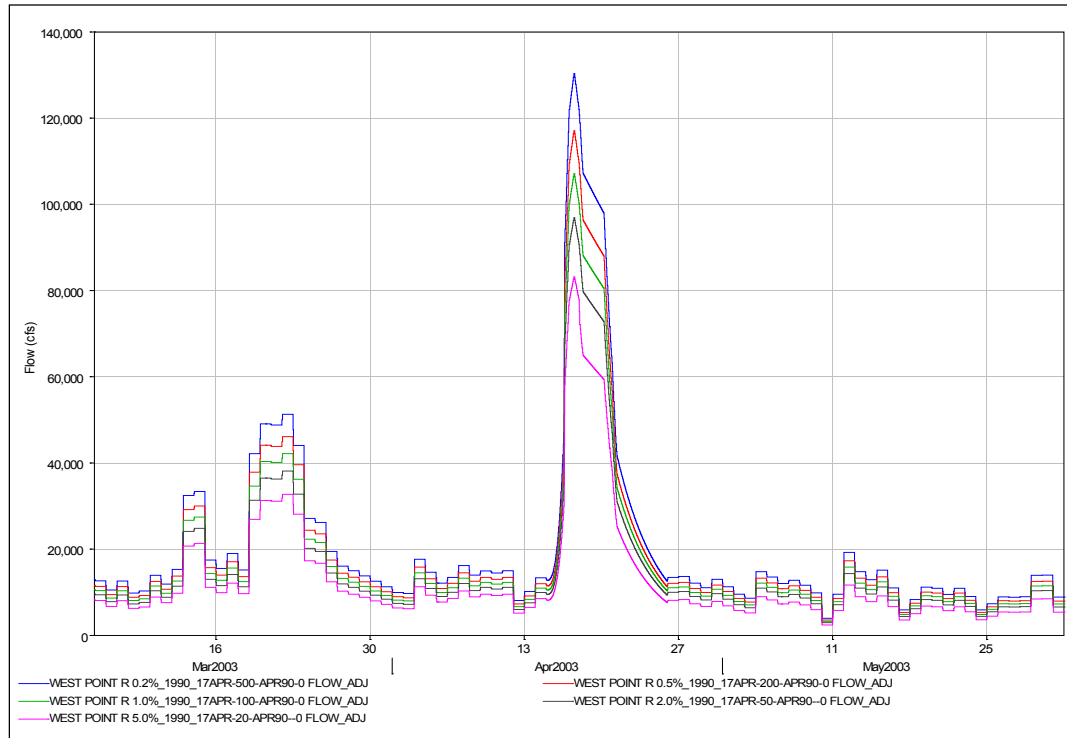


Figure 10. Synthetic Unimpaired Hourly Hydrographs at West Point Based on April 1990 Event

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.

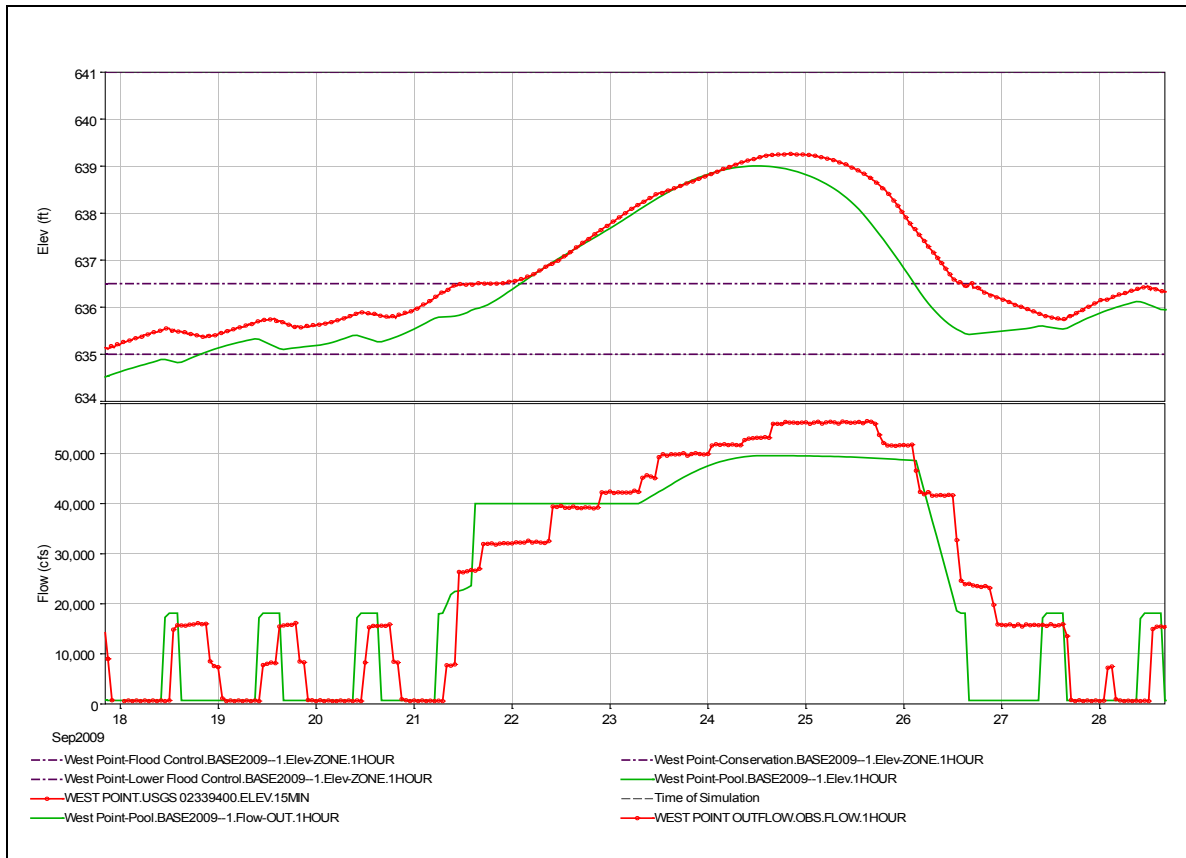


Figure 11. HEC-ResSim Results for September 2009 Event

- 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);

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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	$\geq 34,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 16,000$ and < 34,000	$\geq 16,000 + 50\% \text{ BI} > 16,000$	Up to 50% BI > 16,000
		$\geq 5,000$ and < 16,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
	Zone 3	$\geq 39,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 11,000$ and < 39,000	$\geq 11,000 + 50\% \text{ BI} > 11,000$	Up to 50% BI > 11,000
		$\geq 5,000$ and < 11,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
June – November (Non-spawning season)	Zones 1, 2, and 3	$\geq 22,000$	$\geq 16,000$	Up to 100% BI > 16,000
		$\geq 10,000$ and < 22,000	$\geq 10,000 + 50\% \text{ BI} > 10,000$	Up to 50% BI > 10,000
		$\geq 5,000$ and < 10,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
December – February (Winter)	Zones 1, 2, and 3	$\geq 5,000$	$\geq 5,000$ (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	$\geq 5,000$	
At all times	Zone 4 Or Drought Ops	NA	$\geq 5,000$	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	$\geq 4,500^2$	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

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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).

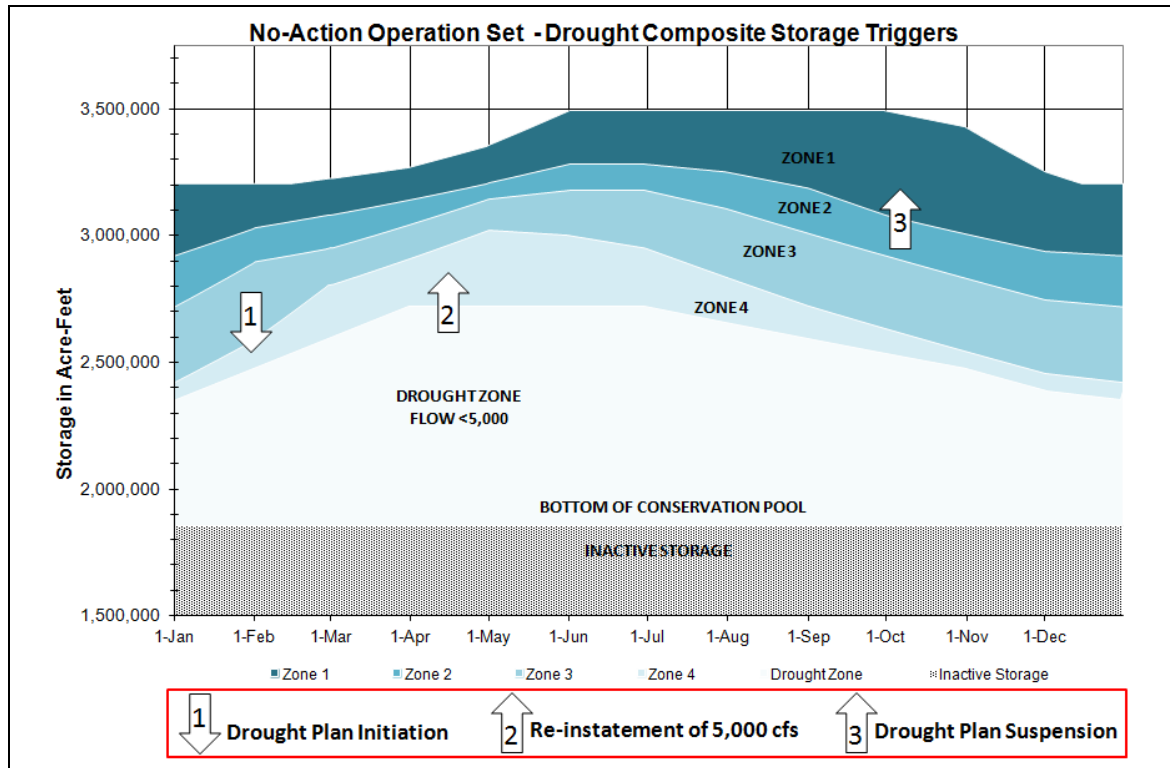


Figure 12. RIOP – Drought Composite Storage Triggers

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 valves 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

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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 in 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.

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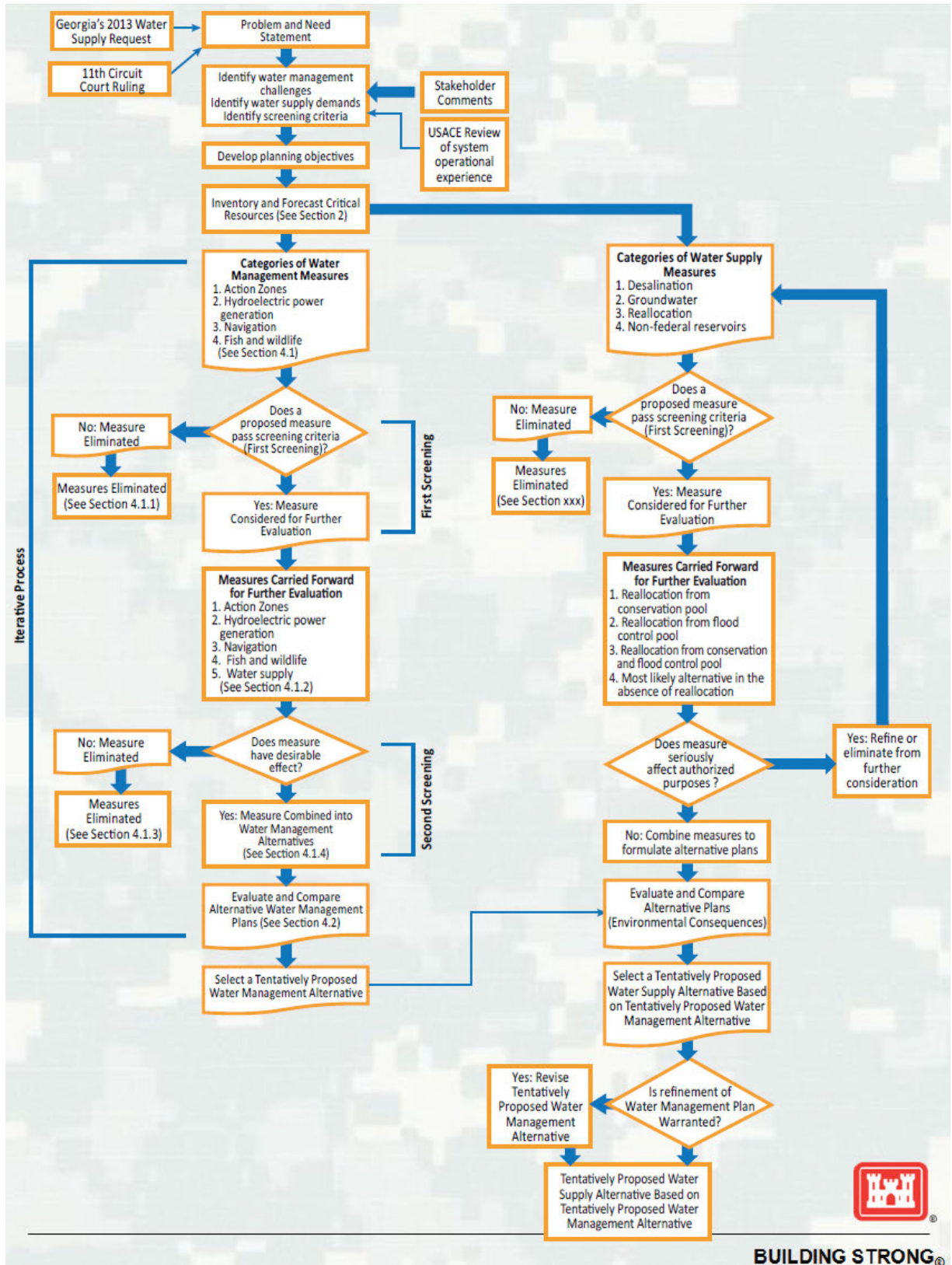


Figure 13. Process of Formulating Management Measures

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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.

Iterative Process Refining Current Operations

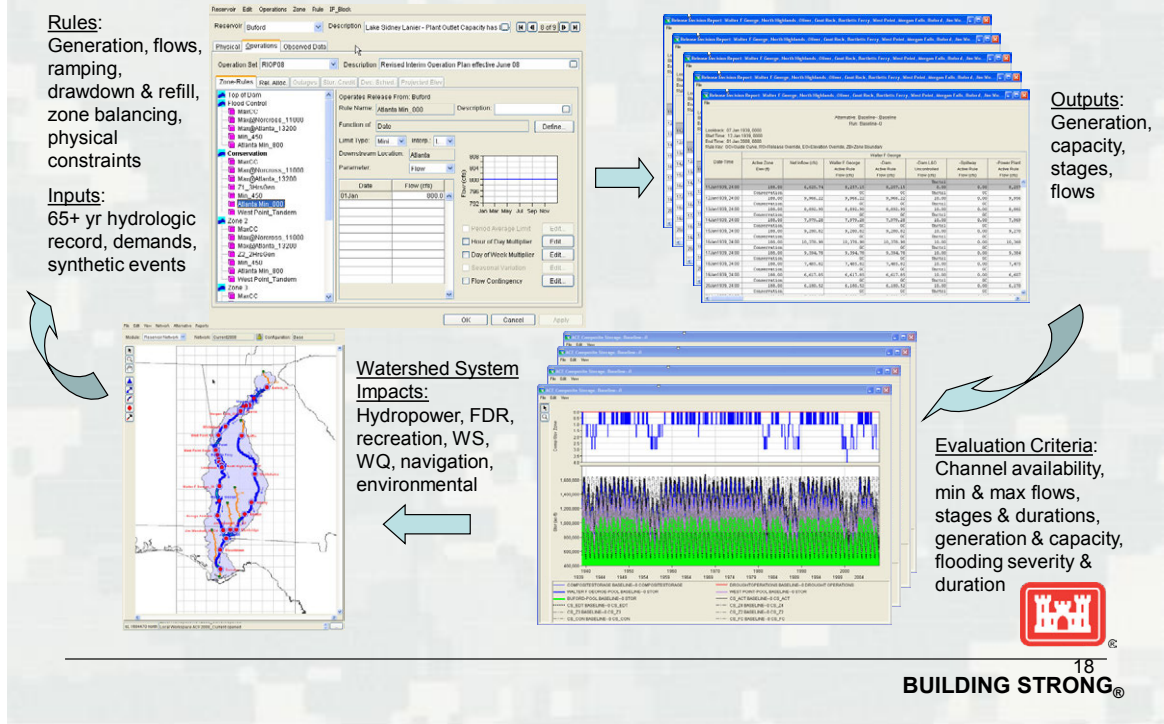


Figure 14. Process of Refining Current Operations

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

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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.

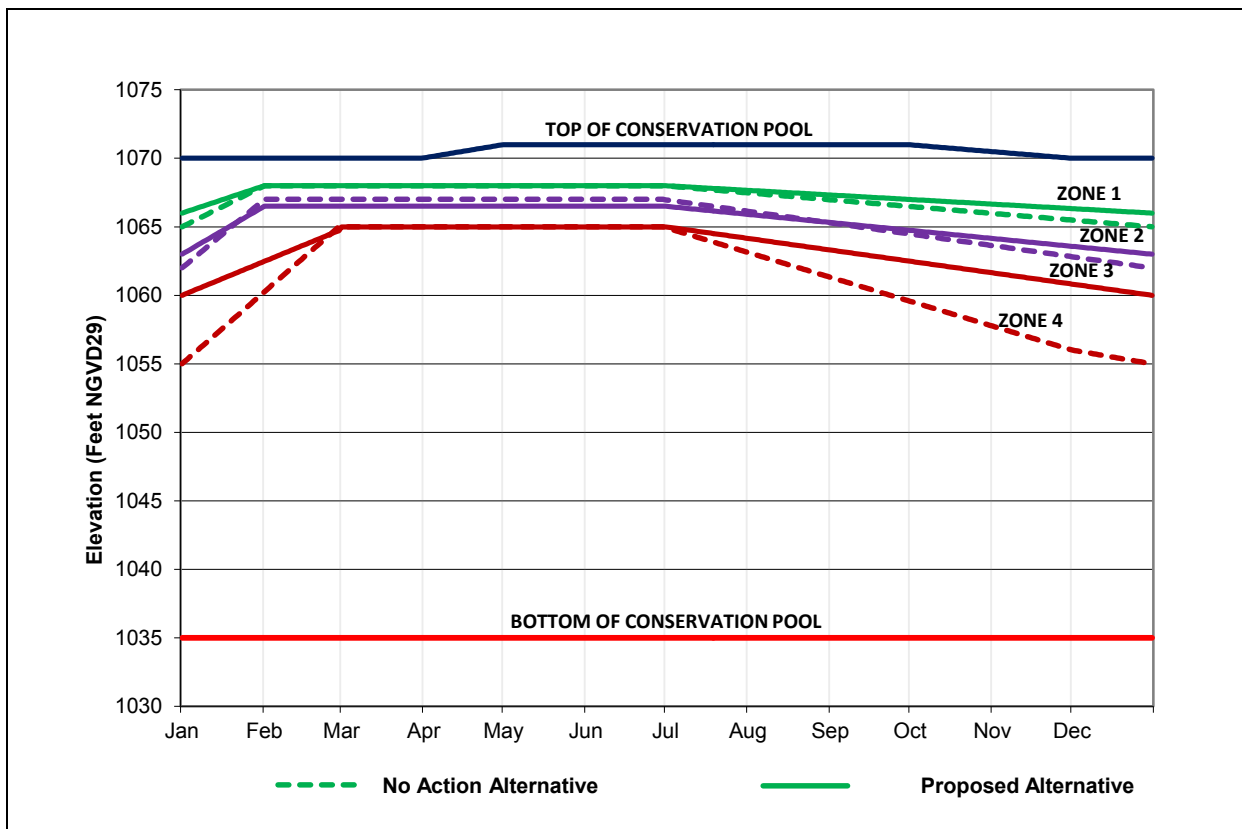


Figure 16. Lake Lanier Water Control Action Zones

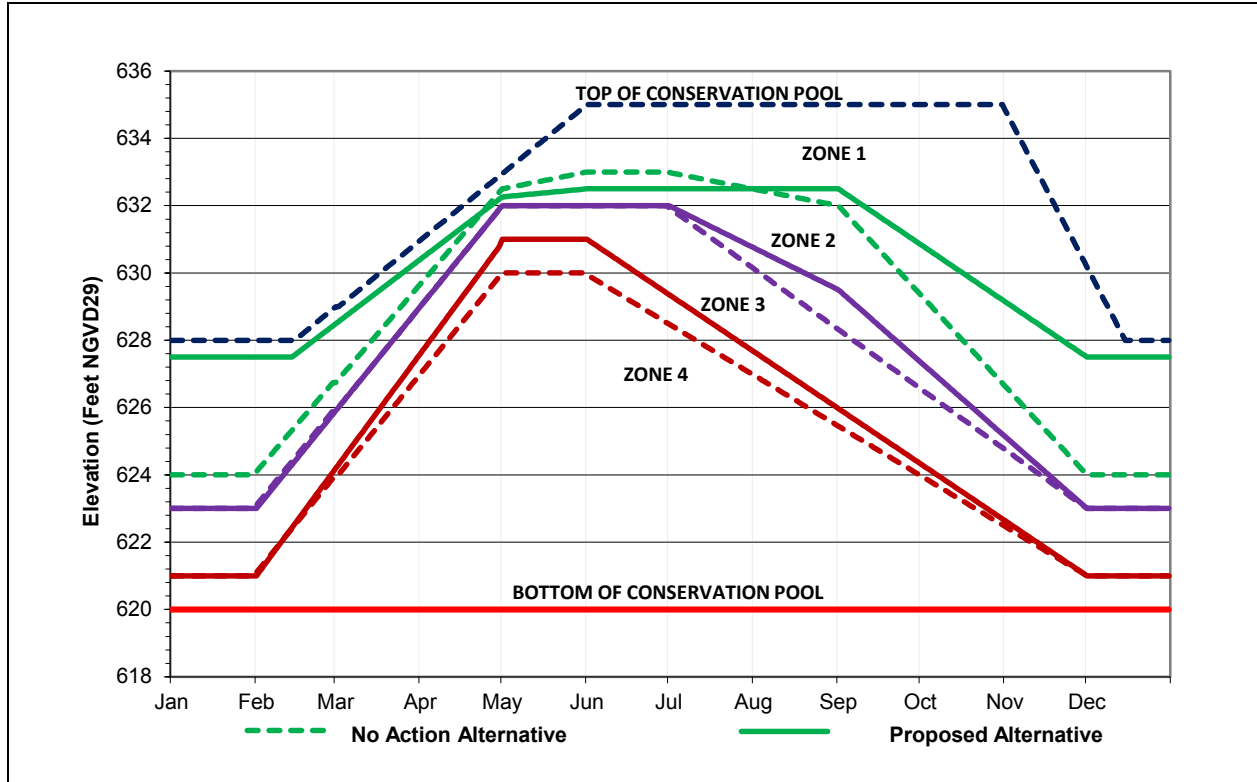


Figure 17. West Point Water Control Action Zones

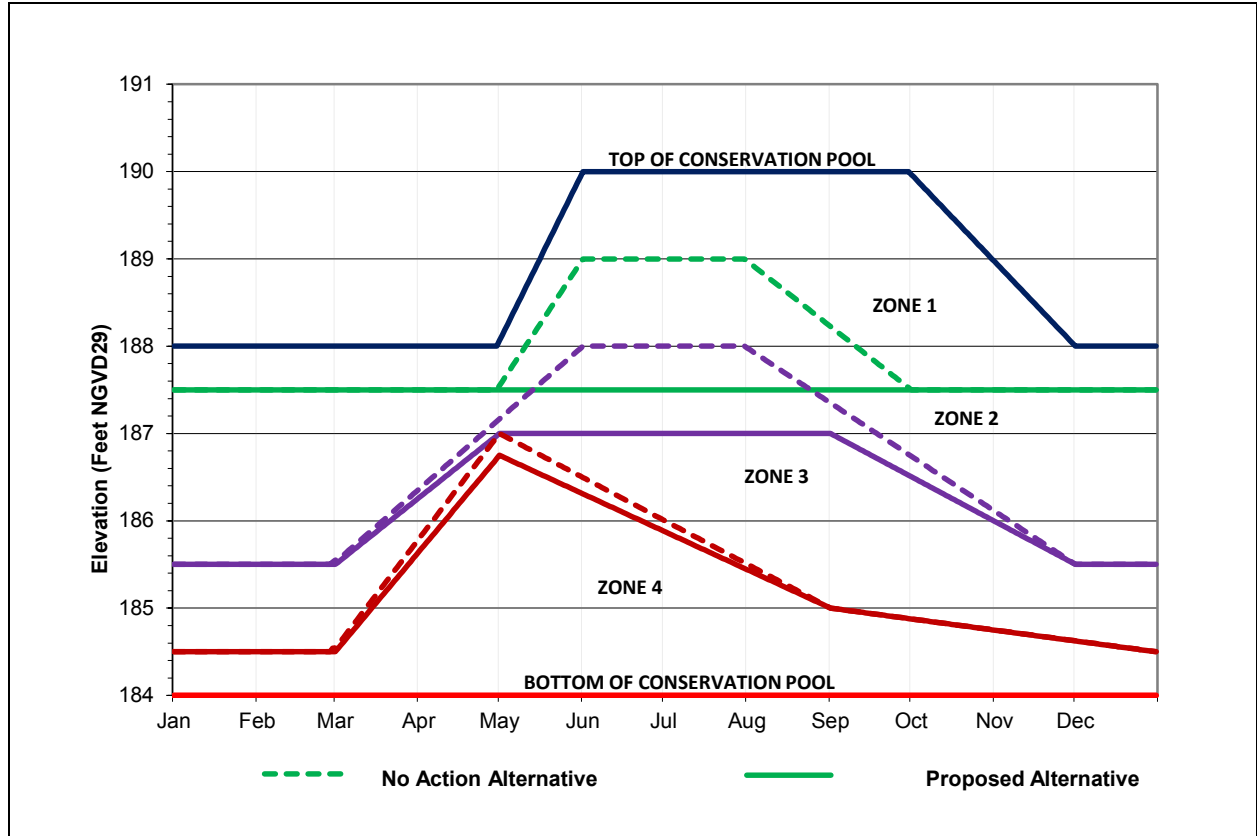


Figure 18. Walter F. George Water Control Action Zones

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	$\geq 34,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 16,000$ and < 34,000	$\geq 16,000 + 50\% \text{ BI} > 16,000$	Up to 50% BI > 16,000
		$\geq 5,000$ and < 16,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
	Zone 3	$\geq 39,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 11,000$ and < 39,000	$\geq 11,000 + 50\% \text{ BI} > 11,000$	Up to 50% BI > 11,000
		$\geq 5,000$ and < 11,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
June – November (Non-spawning season)	Zones 1, 2, and 3	$\geq 22,000$	$\geq 16,000$	Up to 100% BI > 16,000
		$\geq 10,000$ and < 22,000	$\geq 10,000 + 50\% \text{ BI} > 10,000$	Up to 50% BI > 10,000
		$\geq 5,000$ and < 10,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
December – February (Winter)	Zones 1, 2, and 3	$\geq 5,000$	$\geq 5,000$ (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	$\geq 5,000$	
At all times	Zone 4 or Drought Ops	NA	$\geq 5,000$	Up to 100% BI > 5,000
At all times	Exceptional Drought Zone	NA	$\geq 4,500^{**}$	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.

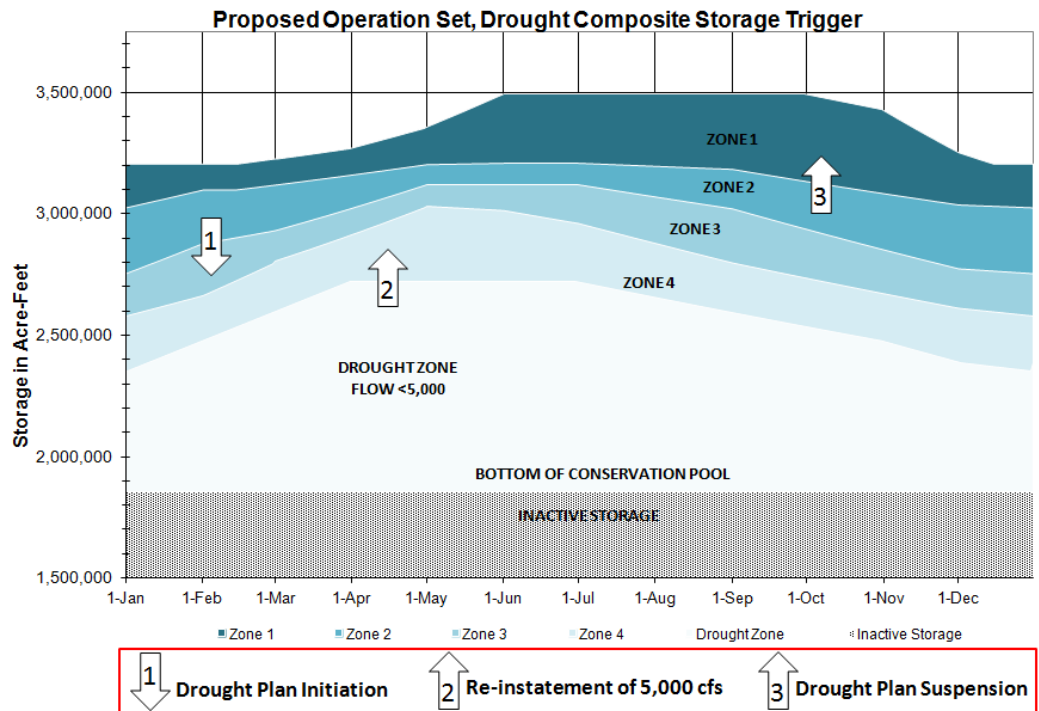


Figure 19. Modified RIOP Composite Storage Triggers

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.

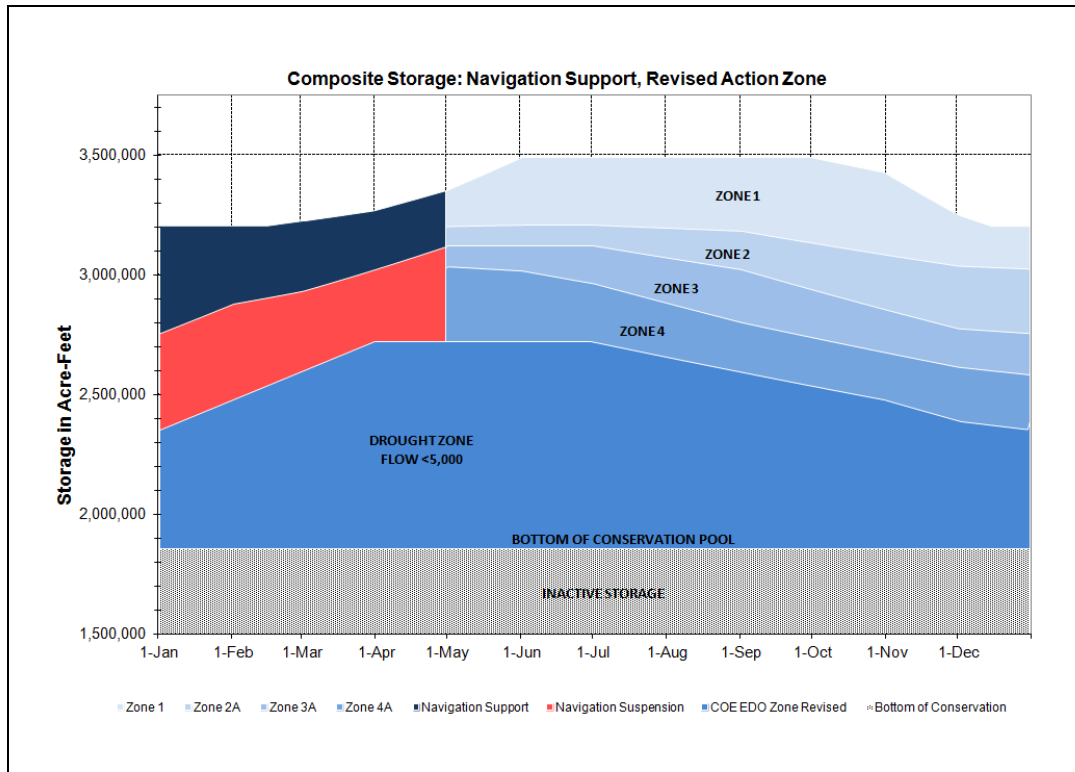


Figure 20. Conservation Storage in a Navigation Season (Jan-May)

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.

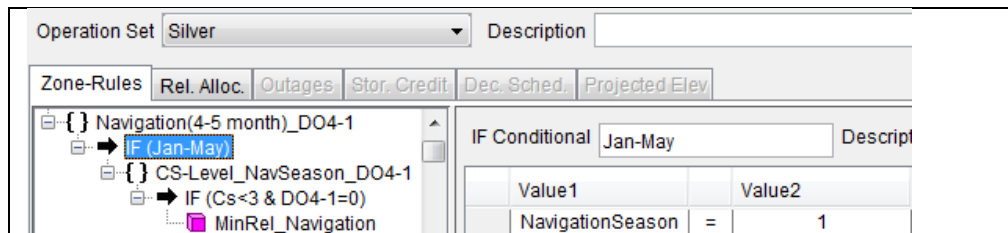


Figure 21. Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

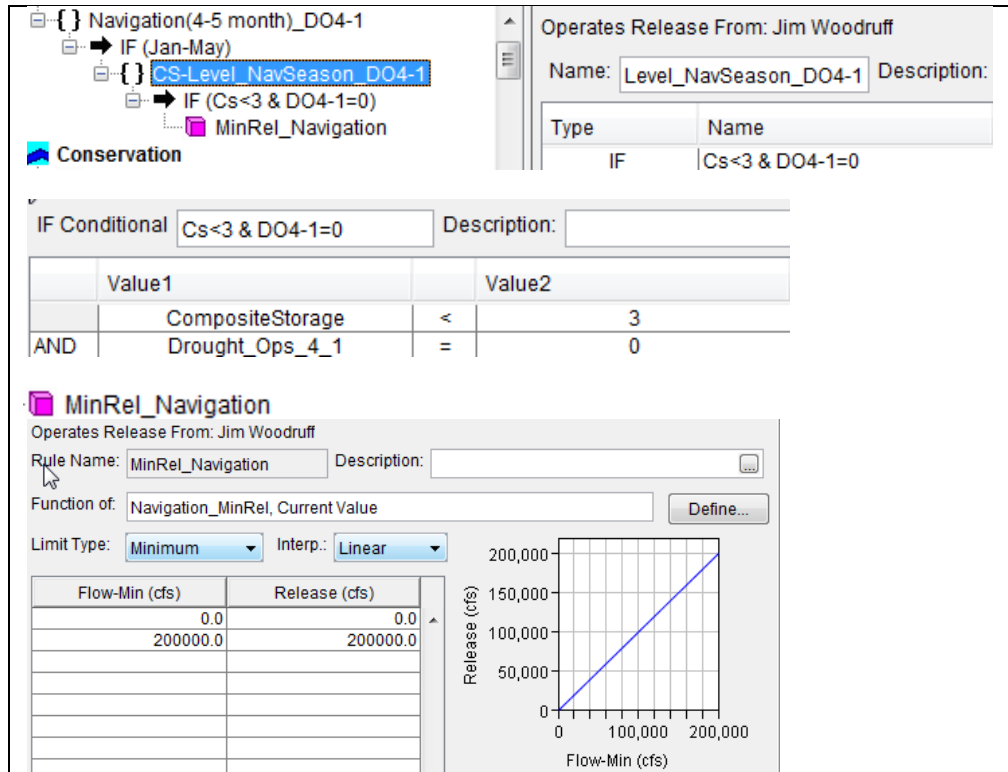


Figure 22. Release Rules for *Navigation(4-5month)_DO4-1* Rule

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*.

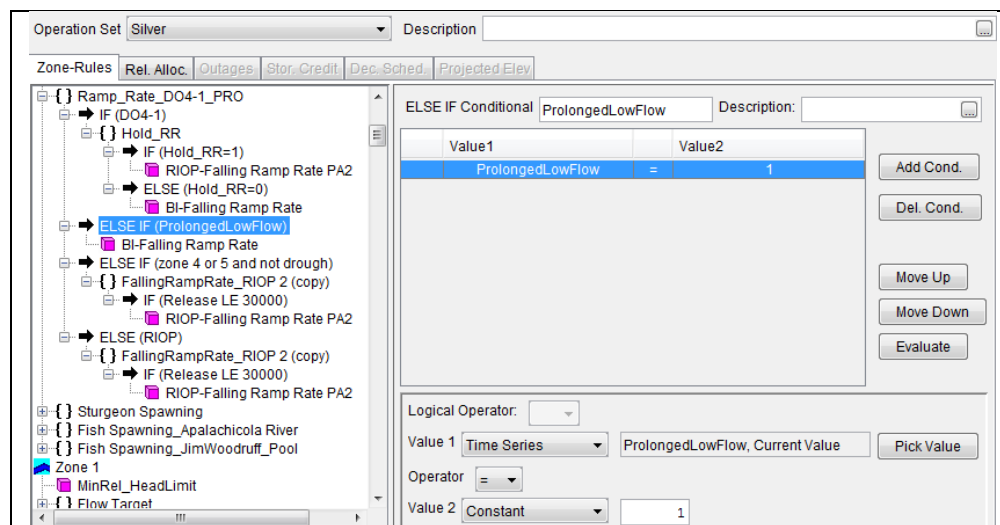


Figure 23. Conditional Block for *Ramp_Rate_DO4-1_PRO* Rule

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.

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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 withdrawals are represented at the inflow to Buford and reflect the 2007 withdrawal levels. This alternative uses the action zones defined in the draft 1989 ACF WCM, current hydroelectric power generation schedules, and current fish and wildlife conservation practices such as spawning 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.

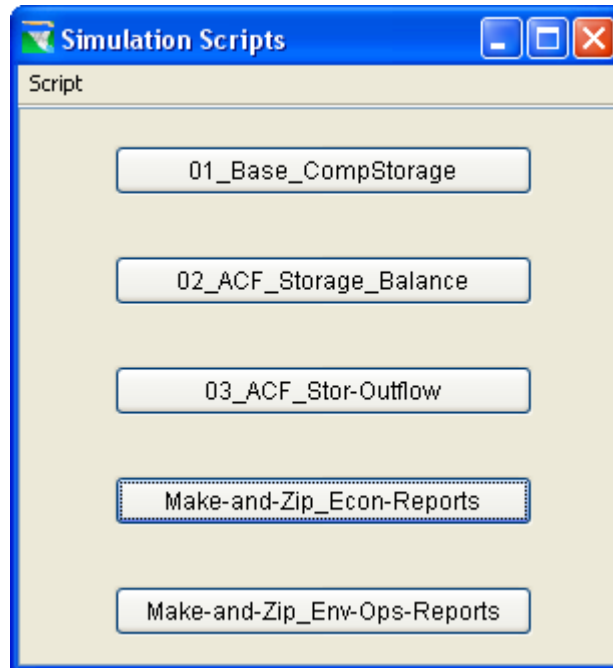


Figure 25. Simulation Scripts for Generating Plots and Reports

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).

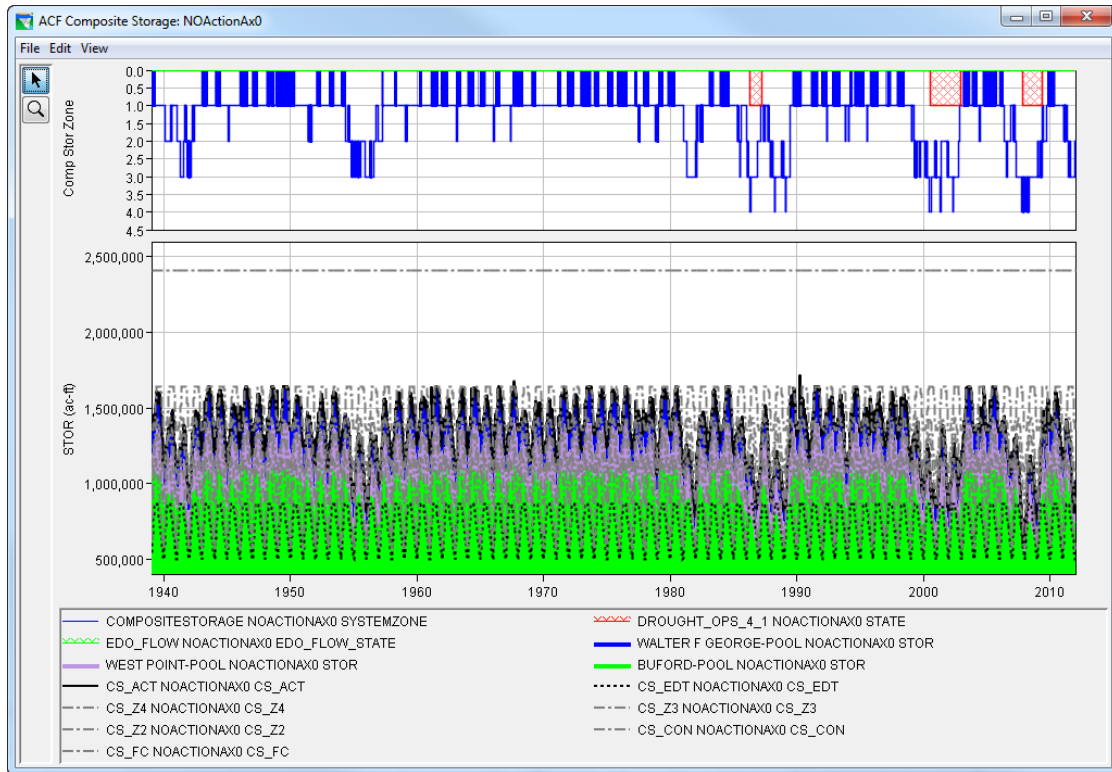


Figure 26. Scripted Plot: Base Composite Storage (POR Simulation, NO-Action Operations)

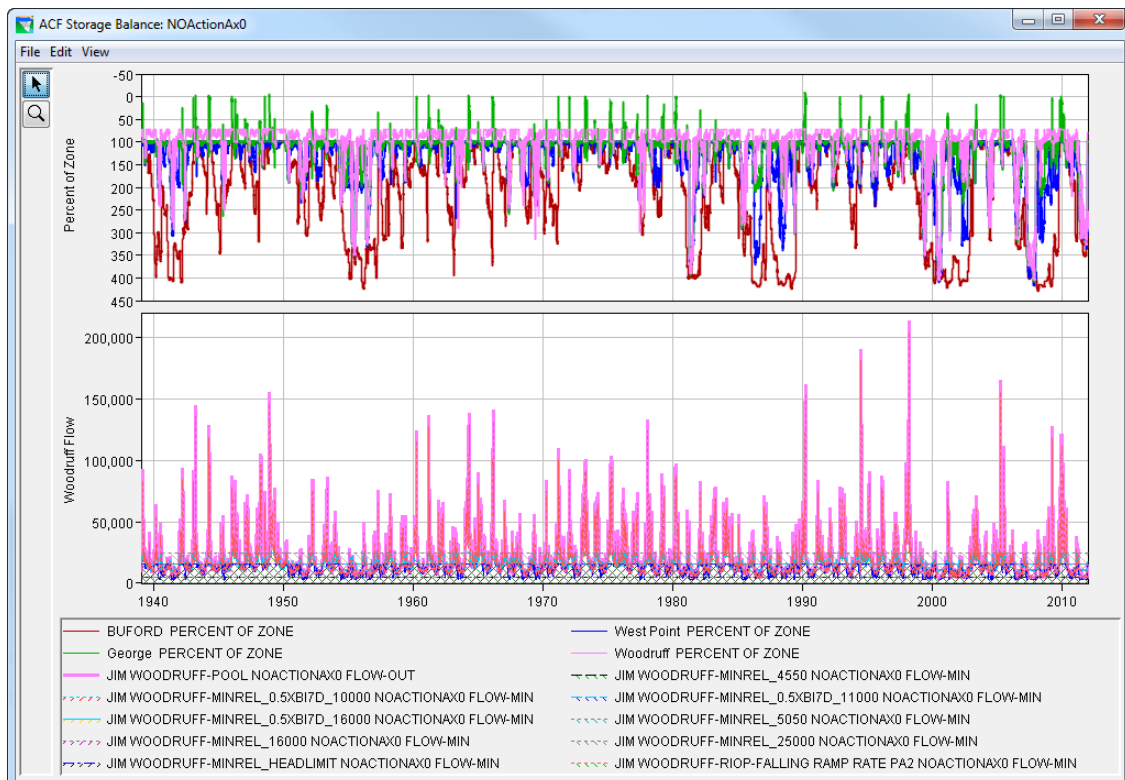


Figure 27. Scripted Plot: Storage Balance (POR Simulation, NO-Action Operations)

ACF ResSim Modeling in Support of WCM Update and WSSA

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).

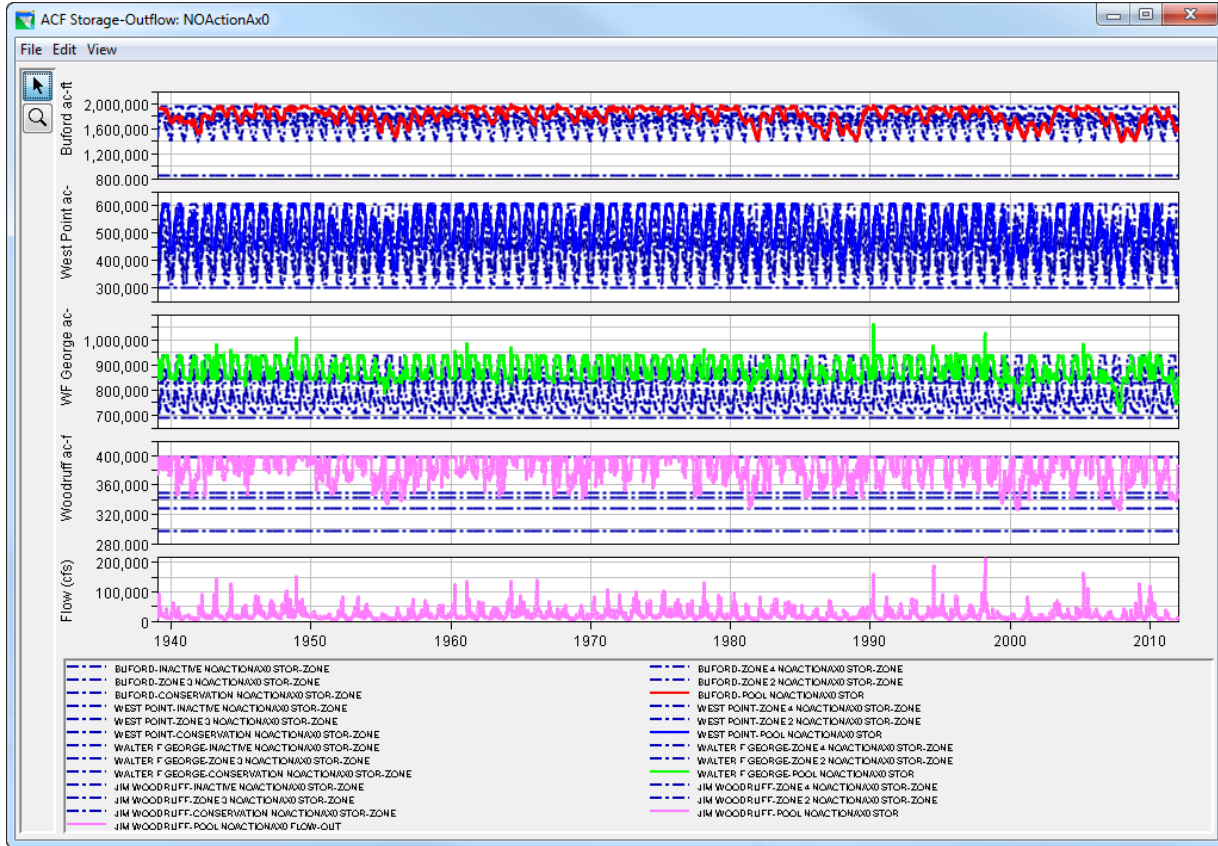


Figure 28. Scripted Plot: Storage Outflow (POR Simulation, NO-Action Operations)

VI. References

Bear Creek 404 Permit, July 2011. JOINT PUBLIC NOTICE: South Fulton Municipal Regional Water and Sewer Authority, Application Number 200900225, Bear Creek Pump-Storage Reservoir, Fulton County, Georgia", July 5, 2011.

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

Glades 404 Permit, June 2011. Proposed Flat Creek Reservoir (Glades Reservoir) Individual Permit Application Hall County, Georgia", June 10, 2011; Hall County Letter to Corps August 10, 2012 (New Preferred Alternative).

GPC, 2007. Georgia Power Company, *Exhibit E – Applicant-Prepared Environmental Assessment*, FERC Project Number 2237, Volume 3, February 2007.

(State of Alabama, Alabama, and Power Company, State of Florida v. United States Army Corps of Engineers), (State of Georgia, Gwinnett County, Georgia, et al., v. United States Army Corps of Engineers), and (City of Apalachicola, Florida v. United States Army Corps of Engineers). MDL-1824 Tri-State Water Rights Litigation. U.S. Court of Appeals, Eleventh Circuit, June 28, 2011. Print.

USACE, 1989. U.S. Army Corps of Engineers, Mobile District, *Apalachicola-Chattahoochee-Flint Basin Water Control Plan*, October 1989.

USACE, 1991. U.S. Army Corps of Engineers, Mobile District, *Apalachicola Basin Reservoir Regulation Manual, Appendix B—Buford Dam (Lake Sidney Lanier)*, February 1991.

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

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

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

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

ACF ResSim Modeling in Support of WCM Update and WSSA

USACE, 2008. U.S. Army Corps of Engineers, Mobile District, *Supplemental Environmental Assessment Modifications to the Interim Operations Plan for Support of Endangered and Threatened Species and Temporary Waiver from ACF Water Control Plan*, June 2008.

USACE, 2009. U.S. Army Corps of Engineers, CECW-CP, Engineering Circular, *Planning Models Improvement Program: Model Calibration (EC 1105-2-412)*, 31Dec2009.

USACE, 2010a. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *ACF ResSim Modeling in Support of WCM Update-Baseline*, August 2010.

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

USACE, 2010c. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *Corps Water Management System, Version 2.0*, October 2010.

USACE, 2011. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *Accelerated Corps Water Management System Deployment Campaign, Appendix 3: Apalachicola-Chattahoochee-Flint River Basin*, Prepared by WEST Consultants, Inc., January 2011.

USACE, 2011. U.S. Army Corps of Engineers, Mobile District, *Update of the Water Control manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin, in Alabama, Florida, and Georgia*, Preliminary Draft, Environmental Impact Statement, April 2011.

USACE, 2012. U.S. Army Corps of Engineers, Mobile District, *Environmental assessment Revised interim Operations Support of Endangered and threatened Jim Woodruff Dam Gadsden and Jackson Counties, Florida and Decatur County, Georgia*, May 2012.

USACE, 2013. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *HEC-ResSim, Reservoir System Simulation, (Version 3.2, Build 3.2.1.19)*, December 2013.

USACE, 2014. U.S. Army Corps of Engineers, Mobile District, *ACT/ACF Comprehensive Water Resource Study, Surface Water Availability Volume I: Unimpaired Flow*, 2014. Under Development.

USFWS, 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River", USFWS, May 22, 2012.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

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

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- B** West Point
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- G** Proposed Reservoirs (Glades, Bear Creek)
- H** State Variables and Utility Scripts
- I** Flood Modeling – West Point to Columbus
- J** Development of Sub-daily Flows from West Point to
Columbus
- K** Development of Alternatives

June 2014

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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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(530) 756-1104
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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.

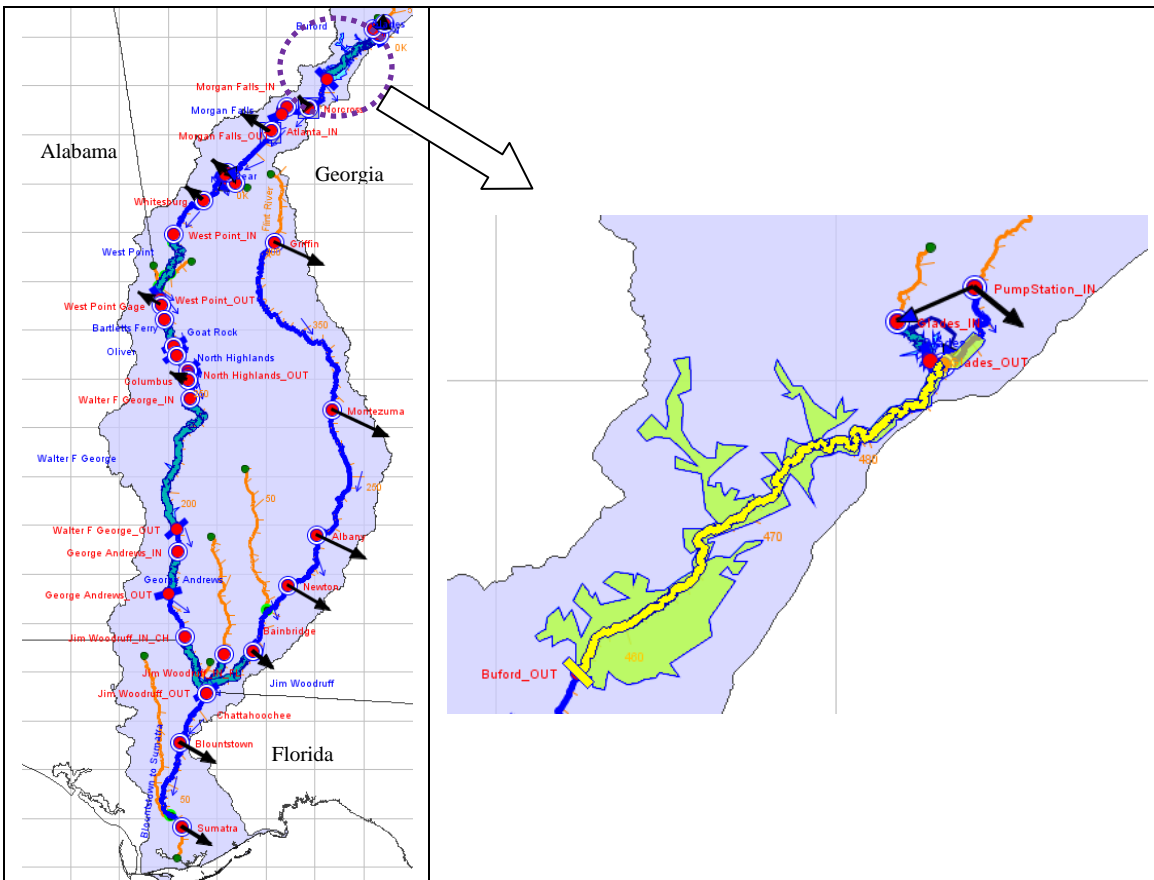


Figure A.01 HEC-ResSim Map Display Showing Location of Buford

Appendix A – 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.

Appendix A – Buford

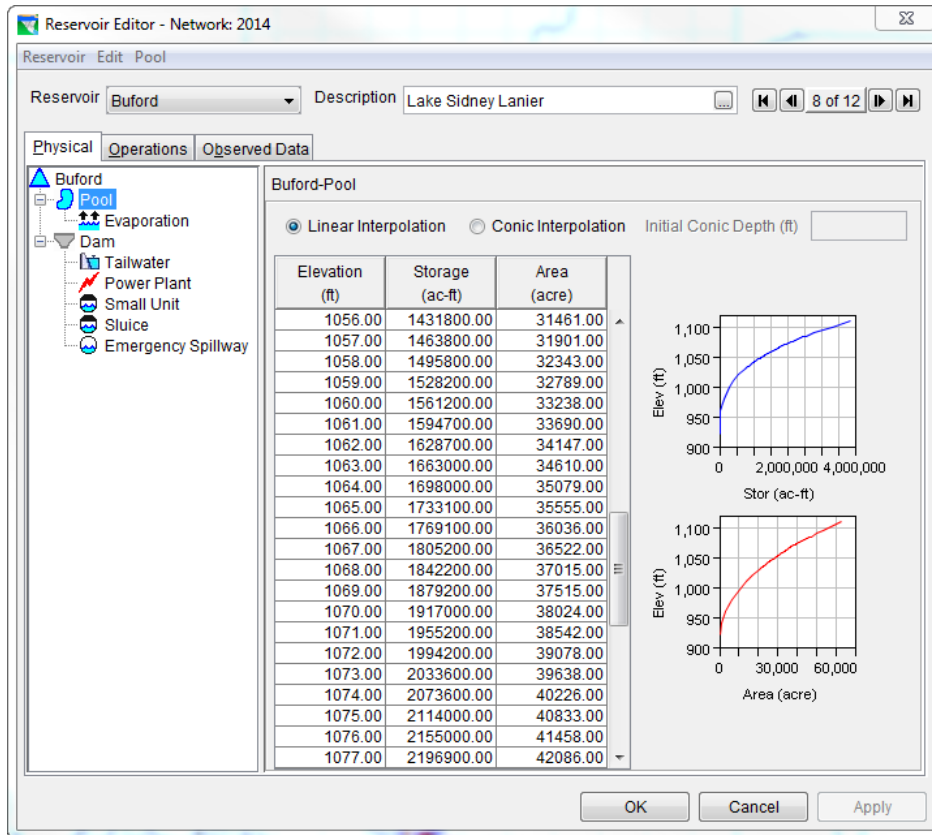


Figure A.03 Reservoir Editor – Network 2014 : Physical Tab -- Pool

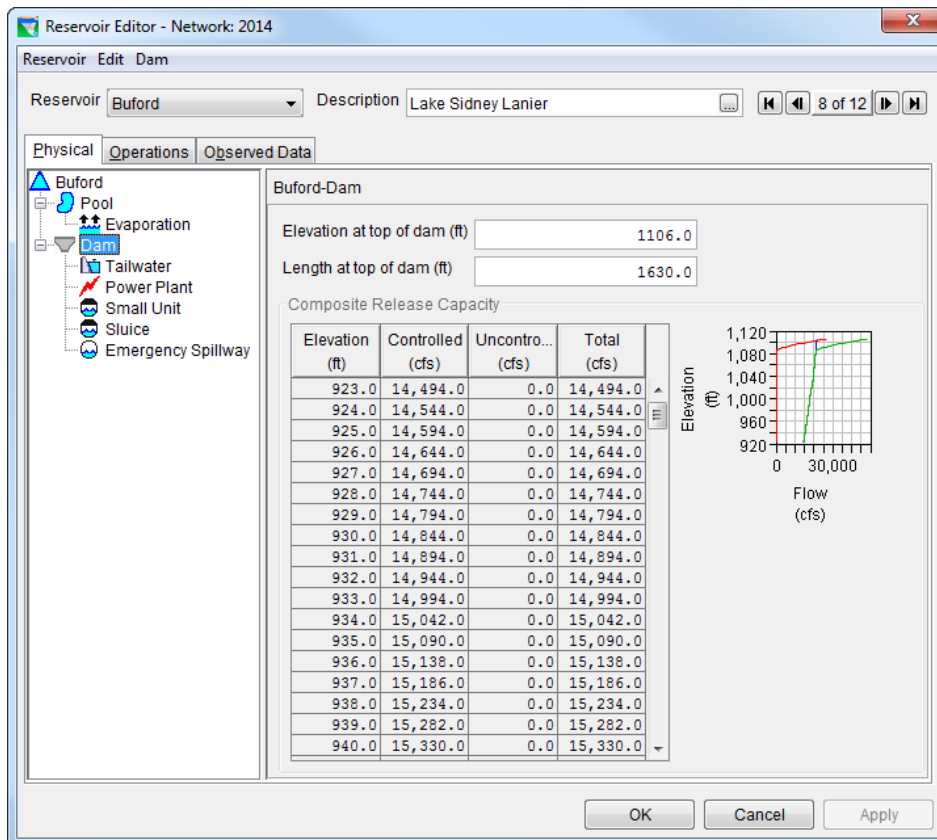


Figure A.04 Reservoir Editor – Network 2014: Physical Tab -- Dam

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 <i>italic</i> values = assumed; Orange <i>linear</i> = 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)

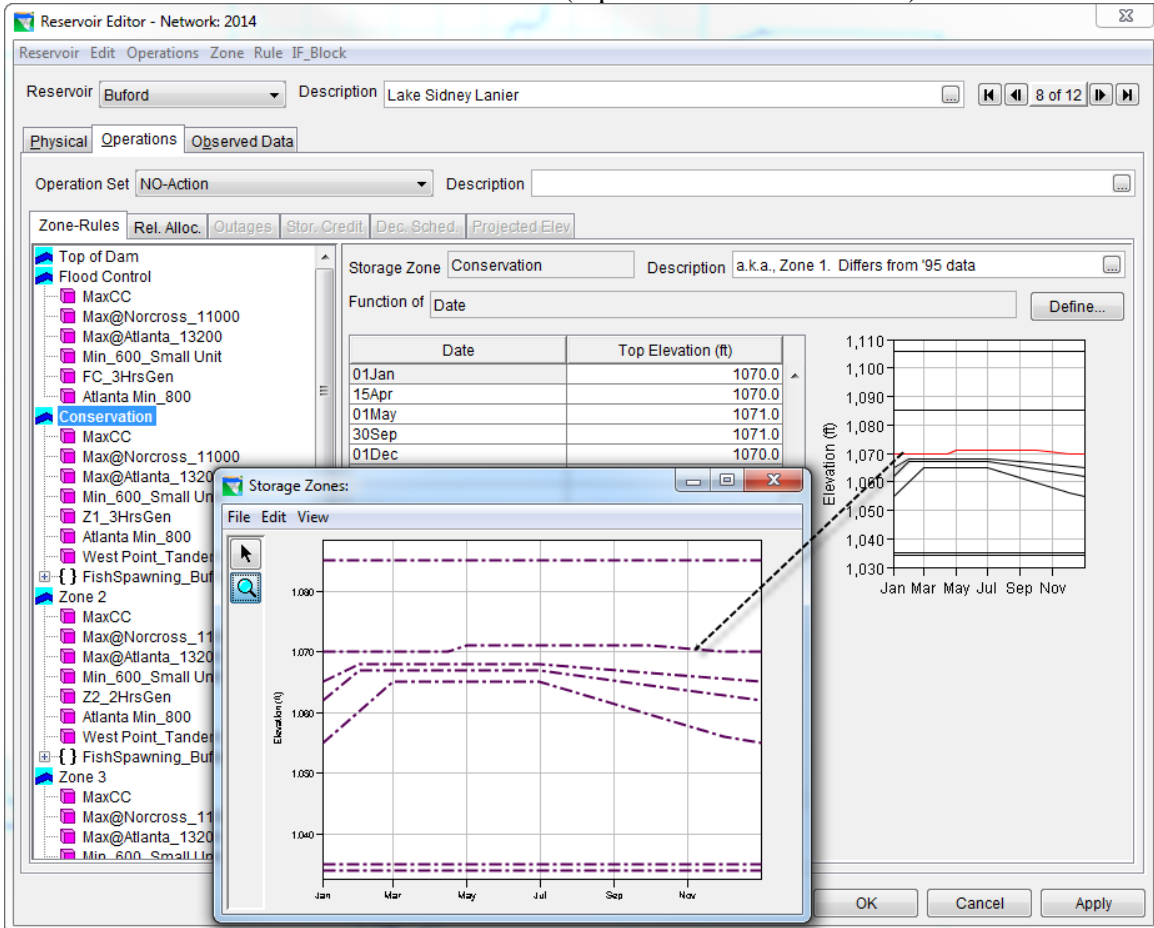


Figure A.05 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

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.

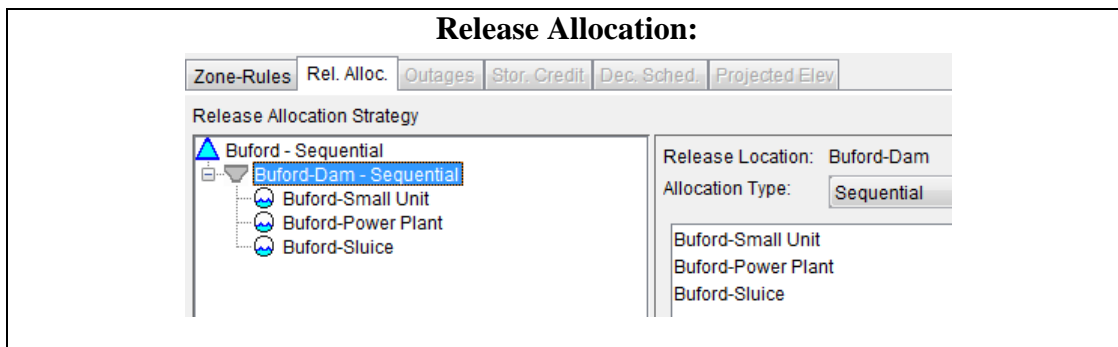


Figure A.06 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

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

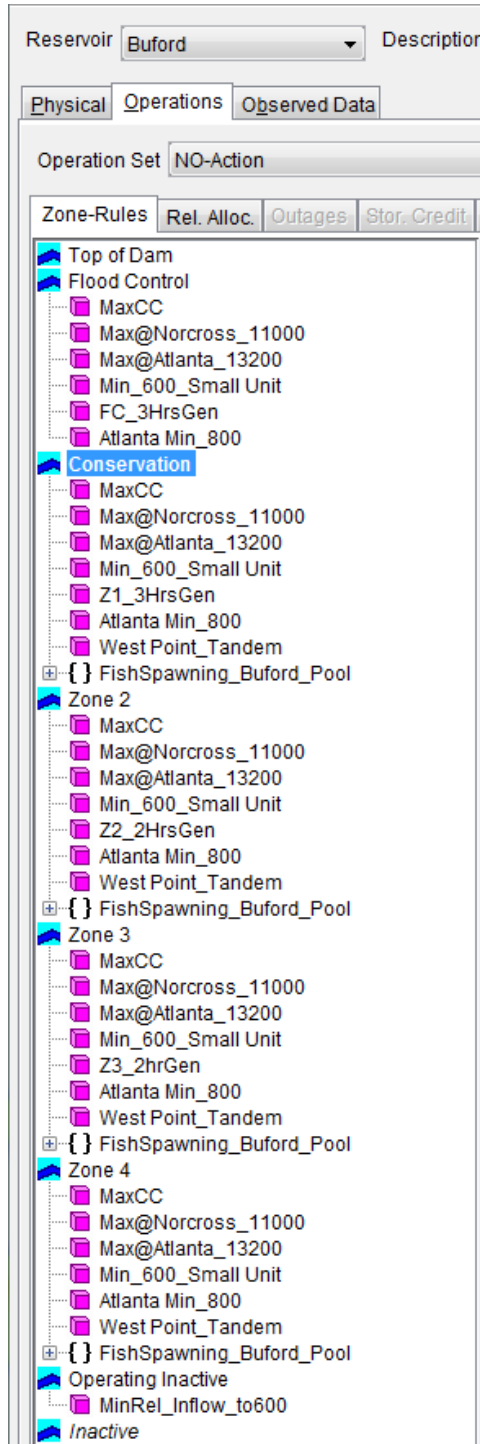


Figure A.07 Reservoir Editor – Network 2014: Operations Tab– NO-Action OpSet – Zones and Rules

Appendix A – Buford

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.

MaxCC
Operates Release From: Buford-Dam
Rule Name: MaxCC Description: Channel Capacity at Buford (CP.2)
Function of: Date
Limit Type: Maximum Interp.: Linear
Table:

Date	Release (cfs)
01Jan	10000.0

Min_600_Small Unit
Operates Release From: Buford-Small Unit
Rule Name: Min_600_Small Unit Description: Minimum release from Small Unit
Function of: Date
Limit Type: Minimum Interp.: Linear
Table:

Date	Release (cfs)
01Jan	600.0

Max@Norcross_11000
Operates Release From: Buford
Rule Name: Max@Norcross_11000 Description:
Function of: Date
Limit Type: Maximum Interp.: Linear
Downstream Location: Norcross
Parameter: Flow
Table:

Date	Flow (cfs)
01Jan	11000.0

Atlanta Min_800
Operates Release From: Buford
Rule Name: Atlanta Min_800 Description: This flow of 800 cfs represents the
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: Atlanta
Parameter: Flow
Table:

Date	Flow (cfs)
01Jan	800.0

Max@Atlanta_13200
Operates Release From: Buford
Rule Name: Max@Atlanta_13200 Description:
Function of: Date
Limit Type: Maximum Interp.: Linear
Downstream Location: Atlanta
Parameter: Flow
Table:

Date	Flow (cfs)
01Jan	13200.0

MinRel_Inflow_to600
Operates Release From: Buford
Rule Name: MinRel_Inflow_to600 Description:
Function of: Buford-Pool Net Inflow, Current Value
Limit Type: Minimum Interp.: Linear
Table:

Flow (cfs)	Release (cfs)
0.0	0.0
600.0	600.0
1000000.0	600.0

WestPoint_Tandem
Operates Release From: Buford
Tandem Operation Rule: WestPoint_Tandem Description: Morgan Falls
Downstream Reservoir: WestPoint
Dialog: Enter Description
Morgan Falls is a 'flow thru'... so Buford will try to balance with West Point thru Morgan Falls.

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

Appendix A – Buford

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 Generation Pattern...

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

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

Power Generation Pattern...

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

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

Power Generation Pattern...

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

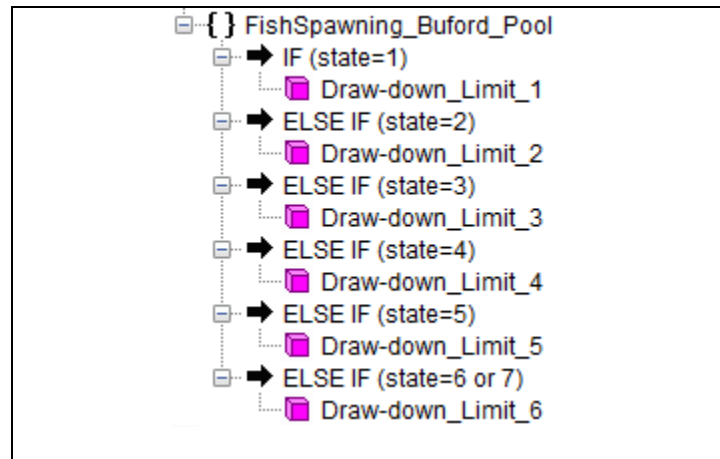


Figure A.11 Fish Spawning -- “IF-Blocks” and “Rules”

The image displays three IF/ELSE IF rules for "Buford_Elev_State" and three corresponding "Draw-down_Limit" rules. Each rule is configured to operate release from "Buford-Dam" or "Buford".

IF (state=1)
 Operates Release From: Buford-Dam
 IF Conditional: state=1
 Value1: Buford_Elev_State, Value2: 1
 Logical Operator: [Dropdown]
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: =
 Value 2: Constant, 1

ELSE IF (state=2)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=2
 Value1: Buford_Elev_State, Value2: 2
 Logical Operator: [Dropdown]
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: =
 Value 2: Constant, 2

ELSE IF (state=3)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=3
 Value1: Buford_Elev_State, Value2: 3
 Logical Operator: [Dropdown]
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: =
 Value 2: Constant, 3

Draw-down_Limit_1
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_1
 Description: [Text]
 Function Of: Constant
 Type: Decreasing
 Instantaneous:
 Period Average:
 Max Change of (ft): 0.1 over 24 hours

Draw-down_Limit_2
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_2
 Description: [Text]
 Function Of: Constant
 Type: Decreasing
 Instantaneous:
 Period Average:
 Max Change of (ft): 0.2 over 24 hours

Draw-down_Limit_3
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_3
 Description: [Text]
 Function Of: Constant
 Type: Decreasing
 Instantaneous:
 Period Average:
 Max Change of (ft): 0.1 over 24 hours

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

Appendix A – Buford

ELSE IF (state=4)
Operates Release From: Buford-Dam

ELSE IF Conditional: state=4 Description:

Value1	Value2
Buford_Elev_State	= 4

Logical Operator:

Value 1: Time Series Buford_Elev_State, Current Value

Operator: =

Value 2: Constant 4

Draw-down_Limit_4
Operates Release From: Buford

Elevation Rate of Change Limit: Draw-down_Limit_4

Description:

Function Of: Constant

Type: Decreasing

Instantaneous

Period Average

Max Change of (ft) 0.05 over 24 hours

ELSE IF (state=5)
Operates Release From: Buford-Dam

ELSE IF Conditional: state=5 Description:

Value1	Value2
Buford_Elev_State	= 5

Logical Operator:

Value 1: Time Series Buford_Elev_State, Current Value

Operator: =

Value 2: Constant 5

Draw-down_Limit_5
Operates Release From: Buford

Elevation Rate of Change Limit: Draw-down_Limit_5

Description:

Function Of: Constant

Type: Decreasing

Instantaneous

Period Average

Max Change of (ft) 0.01 over 24 hours

ELSE IF (state=6 or 7)
Operates Release From: Buford-Dam

ELSE IF Conditional: state=6 or 7 Description:

Value1	Value2
Buford_Elev_State	>= 6

Logical Operator:

Value 1: Time Series Buford_Elev_State, Current Value

Operator: >=

Value 2: Constant 6

Draw-down_Limit_6
Operates Release From: Buford

Elevation Rate of Change Limit: Draw-down_Limit_6

Description:

Function Of: Constant

Type: Decreasing

Instantaneous

Period Average

Max Change of (ft) 0.0 over 24 hours

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:

```
5 # State variable: Buford_Elev_State
6 # Code =0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #  =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #  =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #  =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #  =7: The pool has dropped more than 0.50 ft from the base elevation
14
```

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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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							

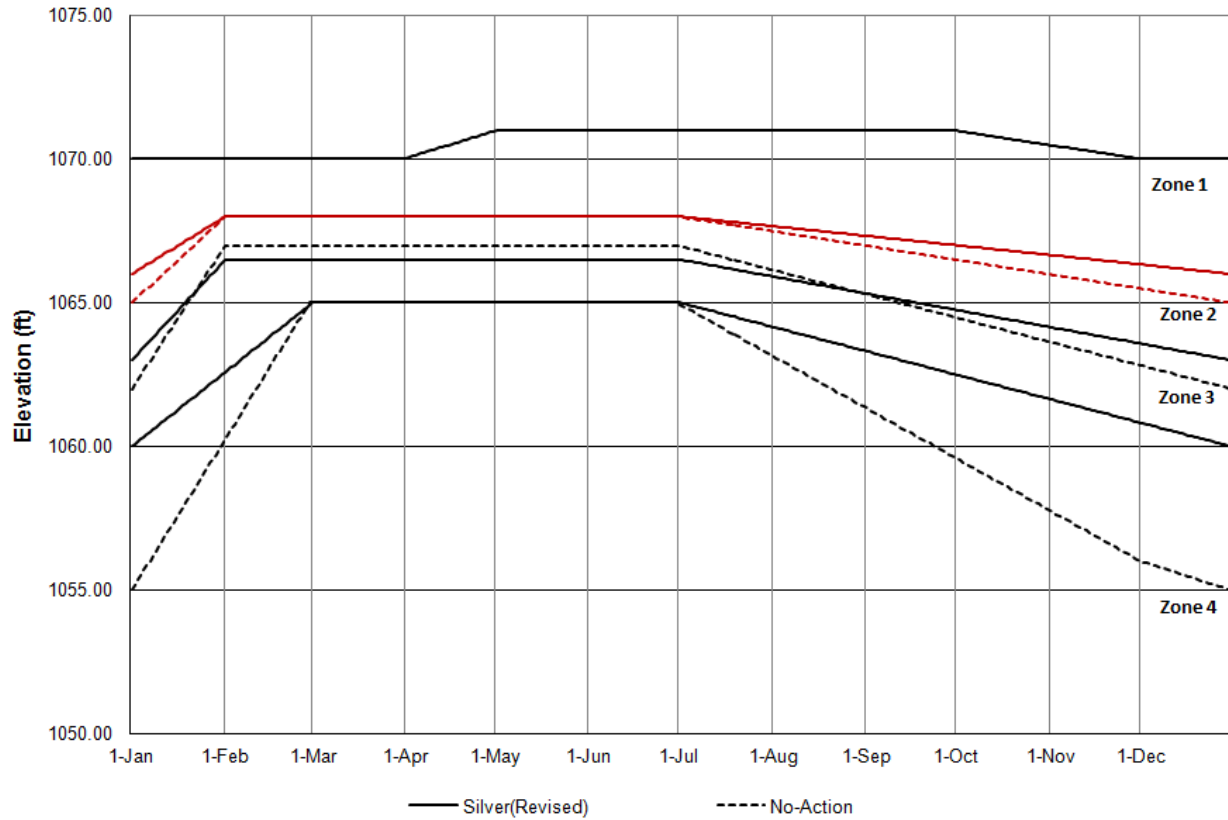


Figure A.14 Comparison of NO-Action and Revised Action Zones at Buford

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.

power Gen fn of drought_FC (*within Flood Control zone*)

Operation Set: Silver Description: This Ops is set for:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Top of Dam
 Flood Control
 MaxCC
 Max@Norcross_11000
 Max@Atlanta_13200
 Min_600_Small Unit
 power Gen fn of drought_FC
 IF (DO4-1 EQ 1)
 2HrsGen_FC
 ELSE (RIOP)
 3HrsGen_FC

Name: power Gen fn of drought_F Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

IF Conditional: DO4-1 EQ 1 Description:

Value1	Value2
Drought_Ops_4_1	= 1

Operates Release From: Buford-Power Plant

ELSE Conditional: RIOP

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_FC

Description: 2 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	8.3
100.0	8.3

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 3HrsGen_FC

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

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

Appendix A – Buford

power Gen fn of drought_Z1 (within Conservation zone)

Operation Set: Silver Description: This Ops is set for.

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Conservation

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z1
 - IF (DO4-1 EQ 1)
 - 2HrsGen_Z1
 - ELSE (RIOP)
 - 3HrsGen_Z1

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z1

Description: 2 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	8.3
100.0	8.3

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 3HrsGen_Z1

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

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

power Gen fn of drought_Z2 (within Zone 2)

Operation Set: Silver Description: This Ops is set for.

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Zone 2

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z2
 - IF (DO4-1 EQ 1)
 - 1HrGen_Z2
 - ELSE (RIOP)
 - 2HrsGen_Z2

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 1HrGen_Z2

Description: 1 hour 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	4.16
100.0	4.16

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z2

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.17 Silver Operation Set Hydropower Rules for Zone 2

power Gen fn of drought_Z3 (within Zone 3)

Operation Set: Silver Description: This Ops is set for:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Zone 3

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z3
 - IF (DO4-1 EQ 1)
 - 1HrGen_Z3
 - ELSE (RIOP)
 - 2HrsGen_Z3

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 1HrGen_Z3

Description: 1 hour generation at full capacity

Zone at Top of Power Pool: Zone 3

Zone at Bottom of Power Pool: Zone 4

% Power Storage	Plant Factor (%)
0.0	4.16
100.0	4.16

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z3

Description: 2 hours of generation at full capacity

Zone at Top of Power Pool: Zone 3

Zone at Bottom of Power Pool: Zone 4

% Power Storage	Plant Factor (%)
0.0	8.3
100.0	8.3

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.

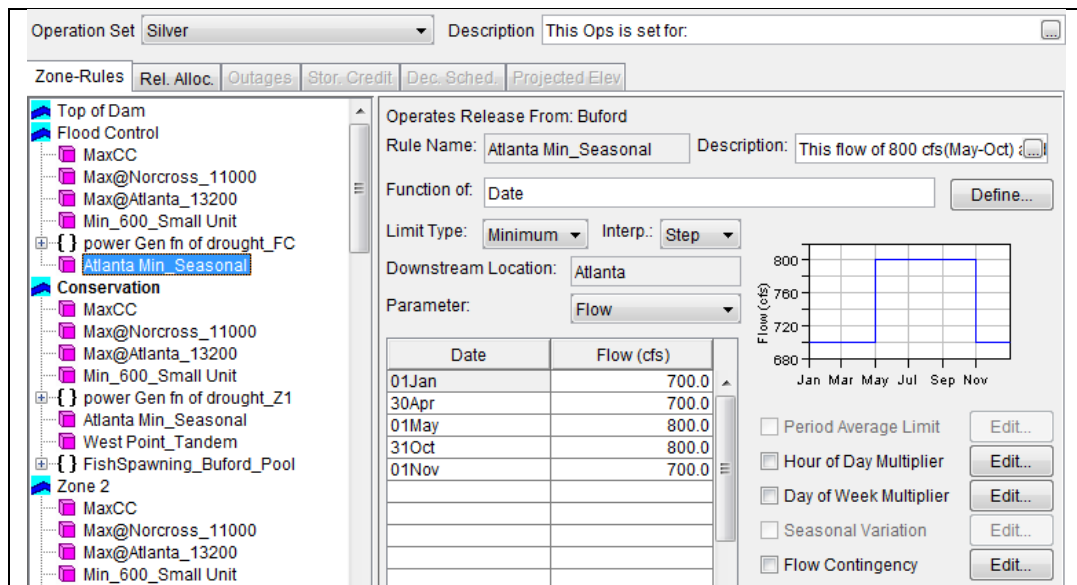


Figure A.17 Silver Operation Set Seasonal Minimum Flow rule at Peach Tree Creek

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.

Operation Set **Blue** Description This Operation set is set for :

Zone-Rules **Rel. Alloc.** Outages Stor. Credit Dec. Sched. Projected Elev

Atlanta Min_Alt6 Name: Atlanta Min_Alt6 Description:

Type	Name	Description
IF	Zone 0,1	
ELSE IF	Zone2	
ELSE IF	Zone3	
ELSE	zone 4,5	

IF Conditional **Zone 0,1** Description:

Value1	Value2
CompositeStorage	<= 1

ELSE IF Conditional **Zone2** Description:

Value1	Value2
CompositeStorage	= 2

ELSE IF Conditional **Zone3** Description:

Value1	Value2
CompositeStorage	= 3

ELSE Conditional **zone 4,5** Description:

Value1	Value2
CompositeStorage	= 3

Atlanta Min_FWS_Z1

Operates Release From: Buford

Rule Name: Atlanta Min_FWS_Z1 Description:

Function of: Date Define...

Limit Type: Minimum Interp.: Step

Downstream Location: Atlanta

Parameter: Flow

Date	Flow (cfs)
01Jan	1910.0
01Feb	2270.0
01Mar	2470.0
01Apr	2400.0
01May	2130.0
01Jun	1610.0
01Jul	1330.0
01Aug	1220.0
01Sep	1010.0
01Oct	1020.0
01Nov	1200.0
01Dec	1410.0

Atlanta Min_FWS_Z2

Operates Release From: Buford

Rule Name: Atlanta Min_FWS_Z2 Description:

Function of: Date Define...

Limit Type: Minimum Interp.: Step

Downstream Location: Atlanta

Parameter: Flow

Date	Flow (cfs)
01Jan	800.0
01Feb	1170.0
01Mar	1390.0
01Apr	1470.0
01May	800.0
01Jun	800.0
01Jul	800.0
01Aug	800.0
01Sep	800.0
01Oct	800.0
01Nov	800.0
01Dec	800.0

Atlanta Min_FWS_Z3

Operates Release From: Buford

Rule Name: Atlanta Min_FWS_Z3 Description:

Function of: Date Define...

Limit Type: Minimum Interp.: Step

Downstream Location: Atlanta

Parameter: Flow

Date	Flow (cfs)
01Jan	700.0
01Feb	700.0
01Mar	800.0
01Apr	800.0
01May	800.0
01Jun	800.0
01Jul	800.0
01Aug	800.0
01Sep	700.0
01Oct	700.0
01Nov	700.0
01Dec	700.0

Atlanta Min_FWS_Z4

Operates Release From: Buford

Rule Name: Atlanta Min_FWS_Z4 Description:

Function of: Date Define...

Limit Type: Minimum Interp.: Step

Downstream Location: Atlanta

Parameter: Flow

Date	Flow (cfs)
01Jan	700.0

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.

The figure displays four screenshots of the Gold Operation Set Hydropower Rules configuration, each for a different zone. Each screenshot shows a tree view of rules on the left and a detailed view of a selected rule on the right.

(within Flood Control zone)
 Operation Set: Gold, Description: This Ops is set for:
 Zone-Rules: Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev.
 Tree View: Top of Dam, Flood Control, MaxCC, Max@Norcross_11000, Max@Atlanta_13200, Min_600_Small Unit, power Gen fn of drought_FC_Alt7 (selected), IF (DO3-1 EQ 1), 2HrsGen_FC, ELSE (RIOP), 3HrsGen_FC.
 Rule Details: Name: power Gen fn of drought_F, Description: [empty].

Type	Name	Description
IF	DO3-1 EQ 1	
ELSE	RIOP	

(within Conservation zone)
 Operation Set: Gold, Description: This Ops is set for:
 Zone-Rules: Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev.
 Tree View: Conservation, MaxCC, Max@Norcross_11000, Max@Atlanta_13200, Min_600_Small Unit, power Gen fn of drought_Z1_Alt7 (selected), IF (DO3-1 EQ 1), 2HrsGen_Z1, ELSE (RIOP), 3HrsGen_Z1.
 Rule Details: Name: power Gen fn of drought_Z, Description: [empty].

Type	Name	Description
IF	DO3-1 EQ 1	
ELSE	RIOP	

(within Zone2)
 Operation Set: Gold, Description: This Ops is set for:
 Zone-Rules: Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev.
 Tree View: Zone 2, MaxCC, Max@Norcross_11000, Max@Atlanta_13200, Min_600_Small Unit, power Gen fn of drought_Z2_Alt7 (selected), IF (DO3-1 EQ 1), 1HrGen_Z2, ELSE (RIOP), 2HrsGen_Z2.
 Rule Details: Name: power Gen fn of drought_Z, Description: [empty].

Type	Name	Description
IF	DO3-1 EQ 1	
ELSE	RIOP	

(within Zone3)
 Operation Set: Gold, Description: This Ops is set for:
 Zone-Rules: Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev.
 Tree View: Zone 3, MaxCC, Max@Norcross_11000, Max@Atlanta_13200, Min_600_Small Unit, power Gen fn of drought_Z3_Alt7 (selected), IF (DO3-1 EQ 1), 1HrGen_Z3, ELSE (RIOP), 2HrsGen_Z3.
 Rule Details: Name: power Gen fn of drought_Z, Description: [empty].

Type	Name	Description
IF	DO3-1 EQ 1	
ELSE	RIOP	

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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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.

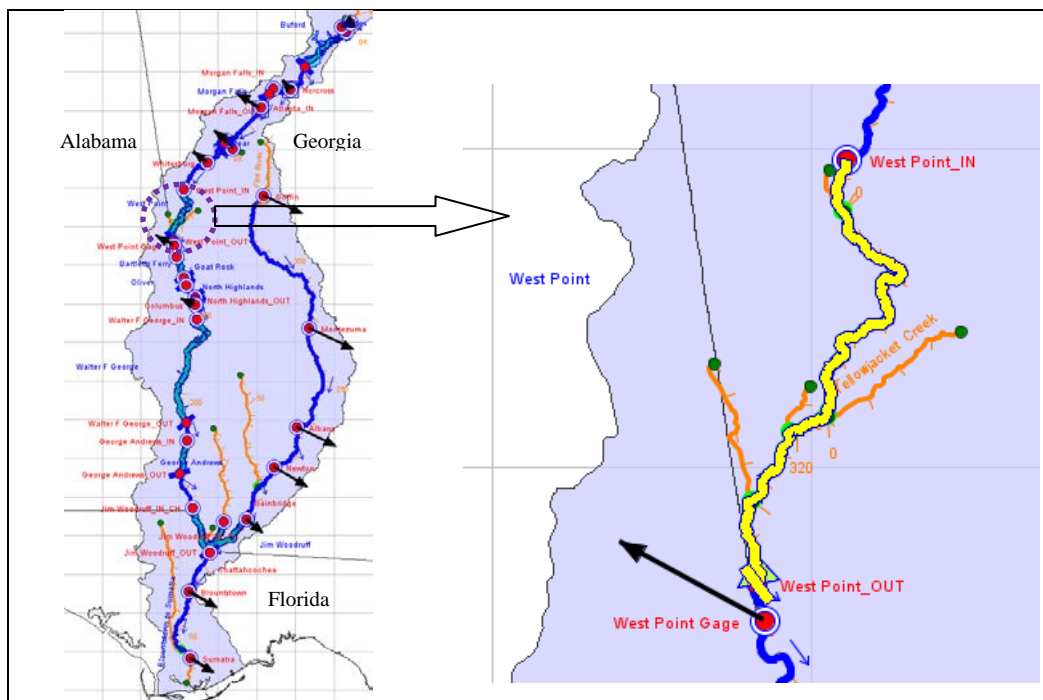


Figure B.01 HEC-ResSim Map Display Showing Location of West Point



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.

Appendix B – West Point

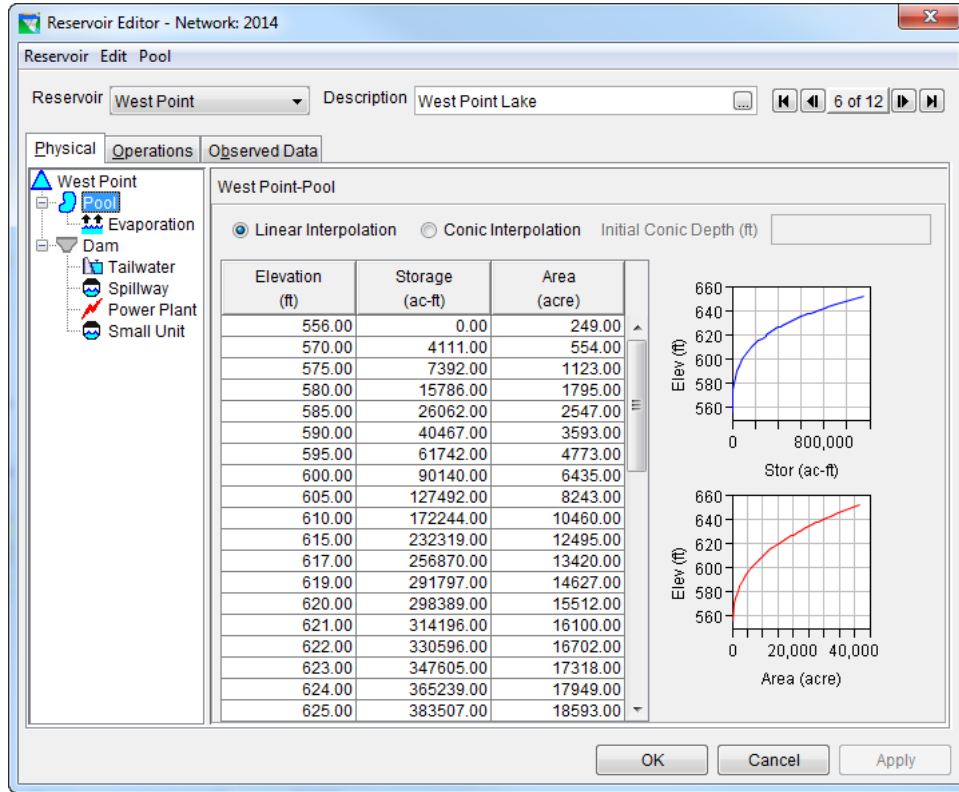


Figure B.03 Reservoir Editor- Network 2014: Physical Tab -- Pool

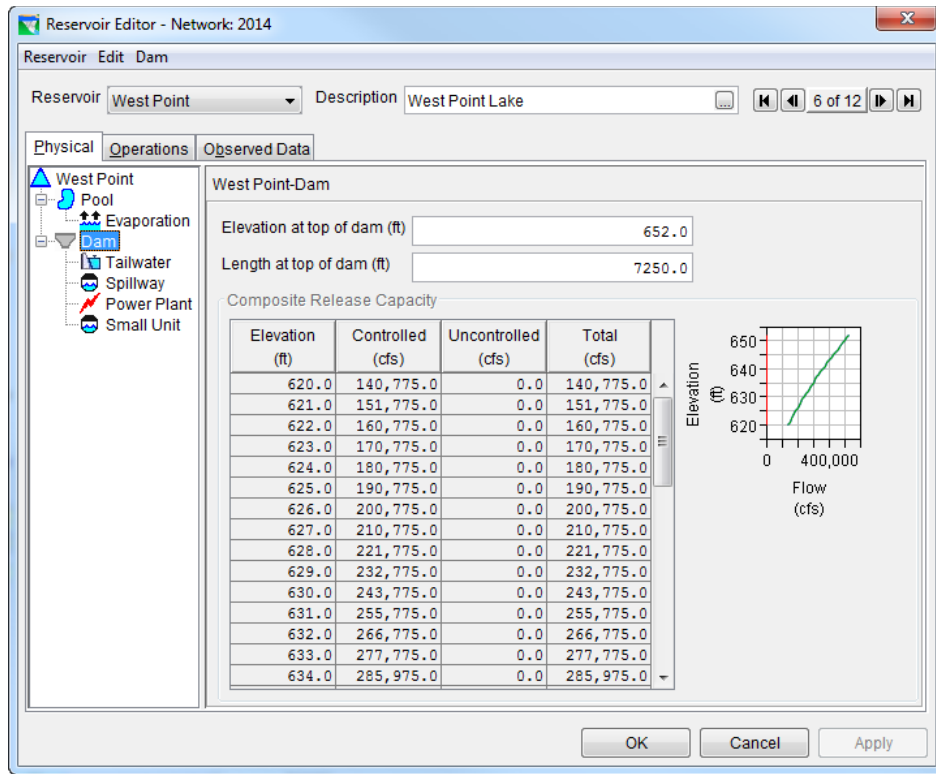


Figure B.04 Reservoir Editor- Network 2014: Physical Tab – Dam

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 <i>italic</i> values = assumed; Orange <i>linear</i> = 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	<i>linear</i>	635	635	635	635	<i>linear</i>	628
Zone 2	624	624	<i>linear</i>	632.5	633	633	632	<i>linear</i>	624	624
Zone 3	623	623	<i>linear</i>	632	632	632	<i>linear</i>	<i>linear</i>	623	623
Zone 4	621	621	<i>linear</i>	630	630	<i>linear</i>	<i>linear</i>	<i>linear</i>	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)

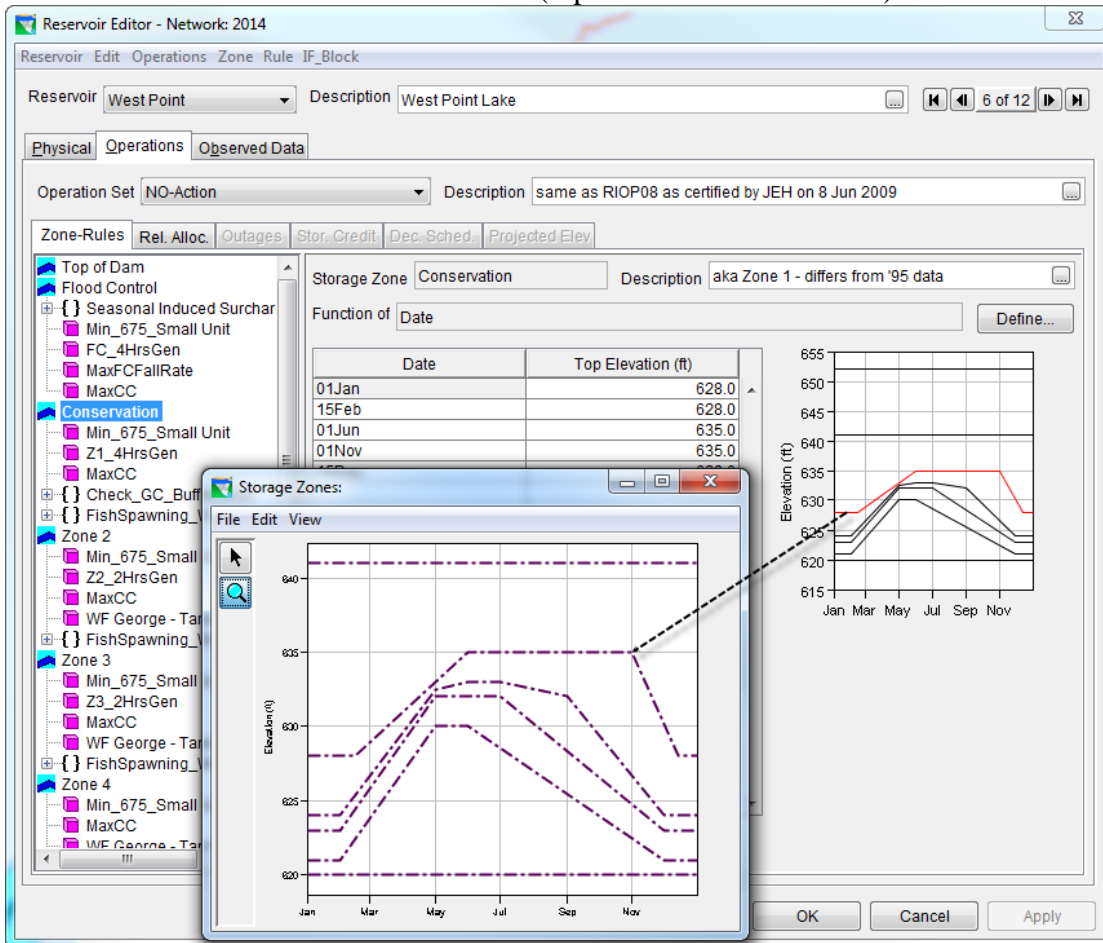


Figure B.05 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

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.

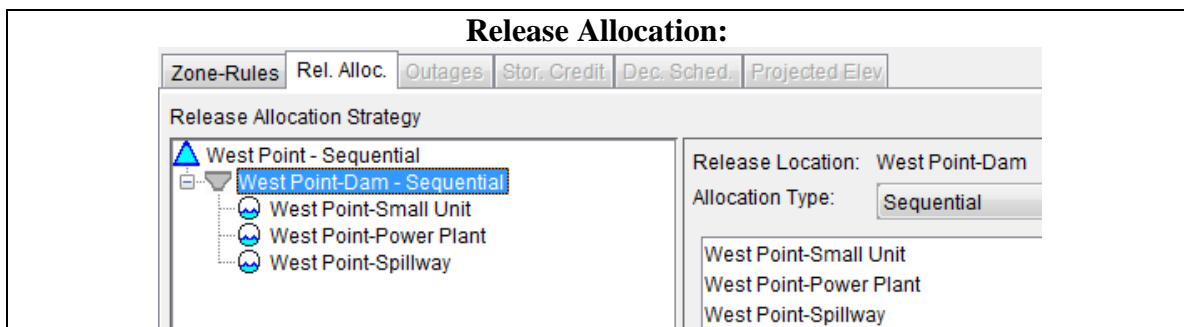
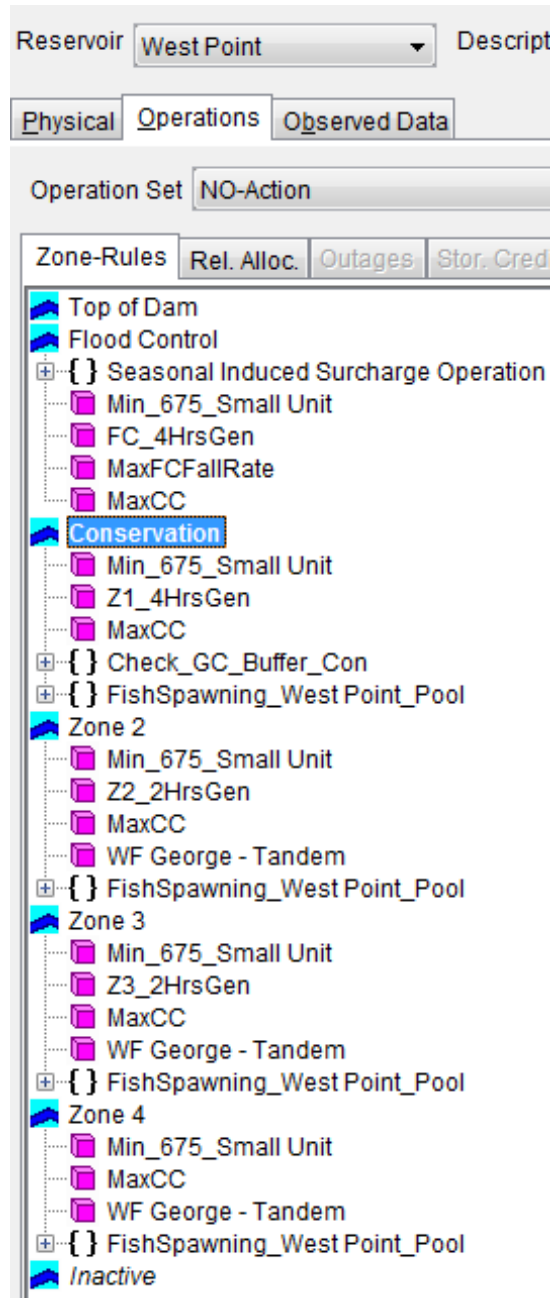


Figure B.06 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

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.

Appendix B – West Point

Min_675_Small Unit

Operates Release From: West Point-Small Unit

Rule Name: Description:

Function of:

Limit Type: Interp.:

Date	Release (cfs)
01Jan	675.0

Period Average Limit

Hour of Day Multiplier

Day of Week Multiplier

Rising/Falling Condition

Seasonal Variation

MaxCC

Operates Release From: West Point-Dam

Rule Name: Description:

Function of:

Limit Type: Interp.:

Date	Release (cfs)
01Jan	40000.0

Period Average Limit

Hour of Day Multiplier

Day of Week Multiplier

Rising/Falling Condition

Seasonal Variation

MaxFCFallRate

Operates Release From: West Point

Release Rate of Change Limit:

Description:

Function Of:

Type:

Max Rate of Change (cfs/hr):

WF George - Tandem

Operates Release From: West Point

Tandem Operation Rule: Description:

Downstream Reservoir:

Check_GC_Buffer_Con

```

graph TD
    A[Check_GC_Buffer_Con] --> B[IF (inBuffer)]
    A --> C[ELSE (not in buffer)]
    B --> D[MaxRel=Inflow]
    C --> E[WF George - Tandem]
    
```

MaxRel=Inflow

Operates Release From: West Point

Rule Name: Description:

Function of:

Limit Type: Interp.:

Flow (cfs)	Release (cfs)
0.0	0.0
40000.0	40000.0
200000.0	40000.0

Period Average Limit

Hour of Day Multiplier

Day of Week Multiplier

Rising/Falling Condition

Seasonal Variation

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

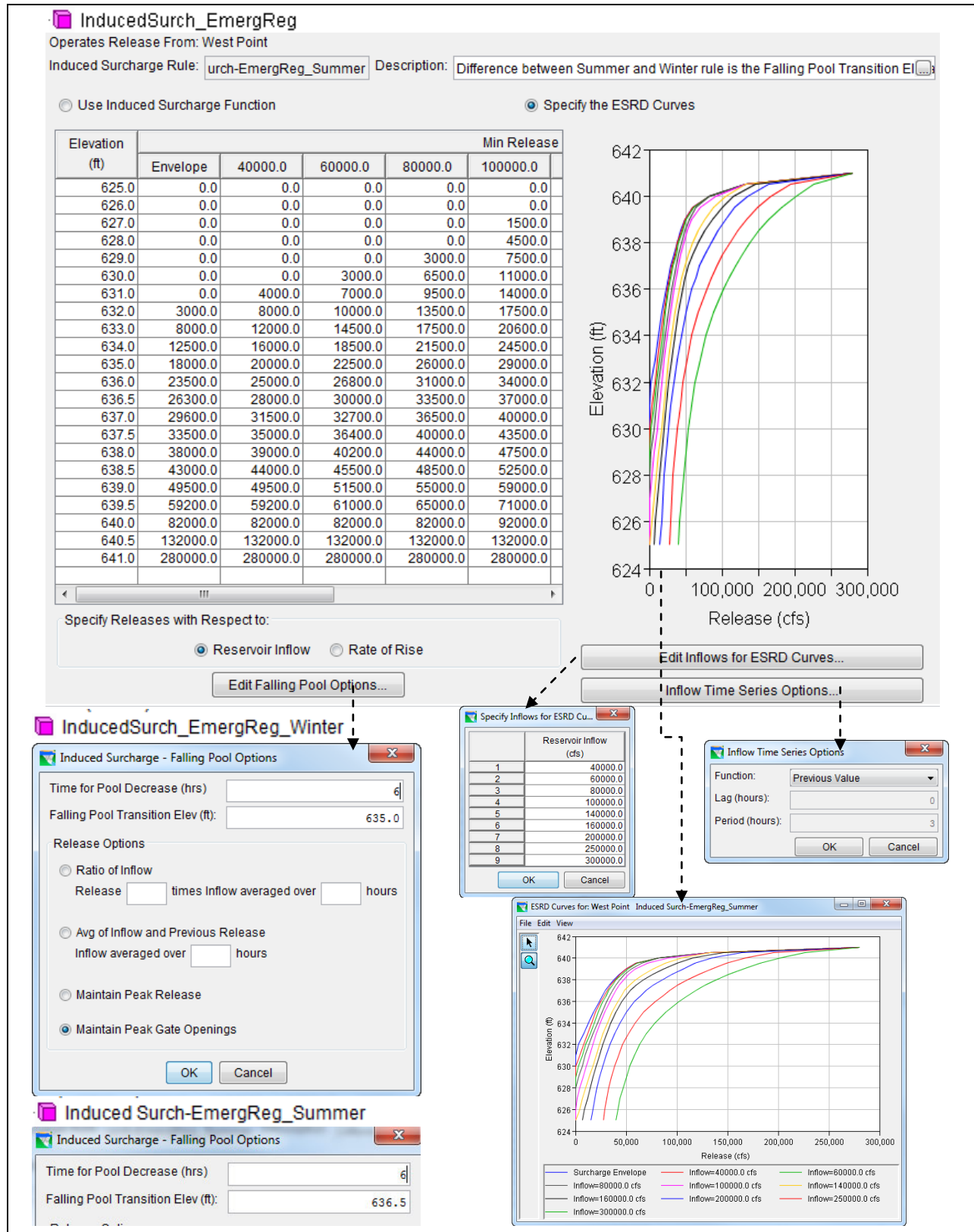


Figure B.09 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Induced Surchage Rule

Appendix B – West Point

FC_4HrsGen (within Flood Control zone)

Operates Release From: West Point-Power Plant
 Hydropower - Power Guide Curve Rule: FC_4HrsGen
 Description: 4 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	16.67
100.0	16.67

Z1_4HrsGen (within Conservation zone)

Operates Release From: West Point-Power Plant
 Hydropower - Power Guide Curve Rule: Z1_4HrsGen
 Description: 4 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	16.67
100.0	16.67

Z2_2HrsGen (within Zone 2)

Operates Release From: West Point-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	8.33
100.0	8.33

Z3_2HrsGen (within Zone 3)

Operates Release From: West Point-Power Plant
 Hydropower - Power Guide Curve Rule: Z3_2HrsGen
 Description: 2 hours of generation at full capacity

Zone at Top of Power Pool: Zone 3
 Zone at Bottom of Power Pool: Zone 4

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

**Power Generation Pattern -- Weekdays and Weekend
(for all Hydropower rules shown above)**

Power Generation Pattern

Seasonal Variation Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

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

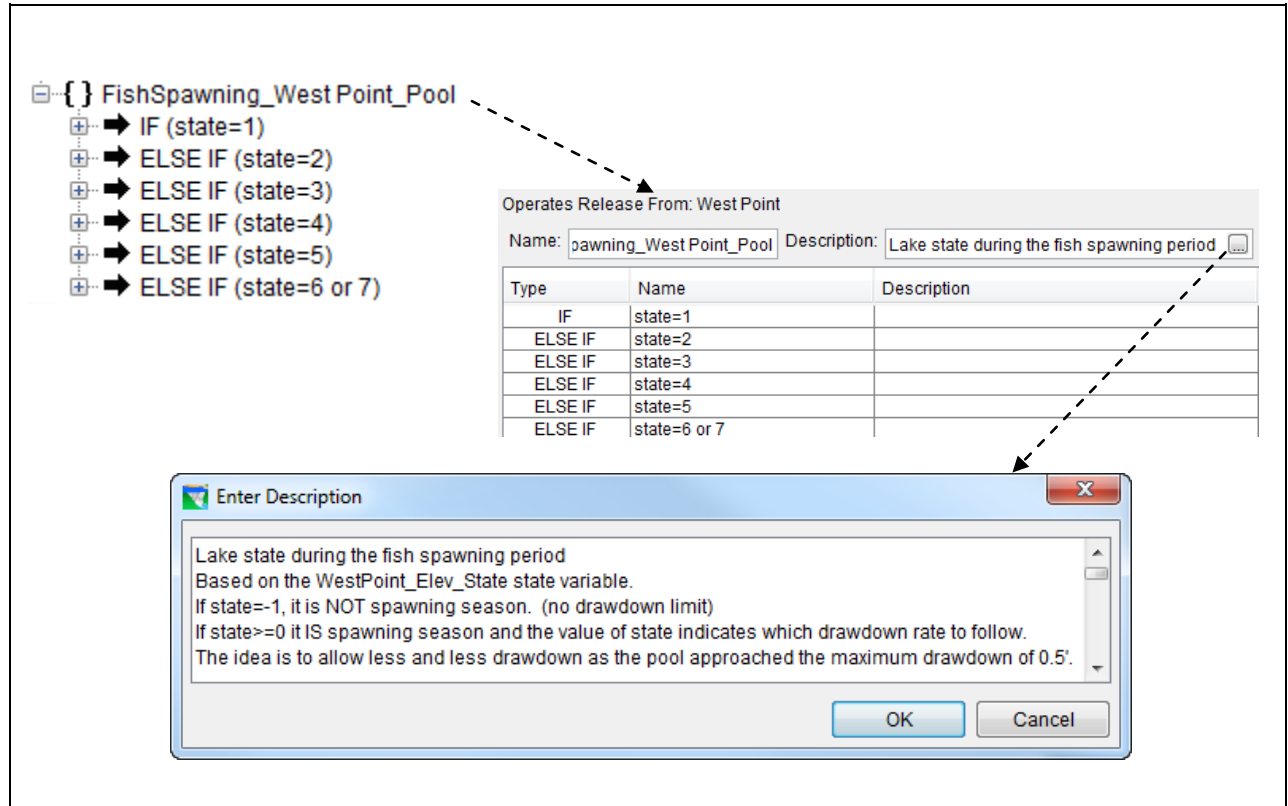


Figure B.11 Fish Spawning -- “Conditional Blocks”

Appendix B – West Point

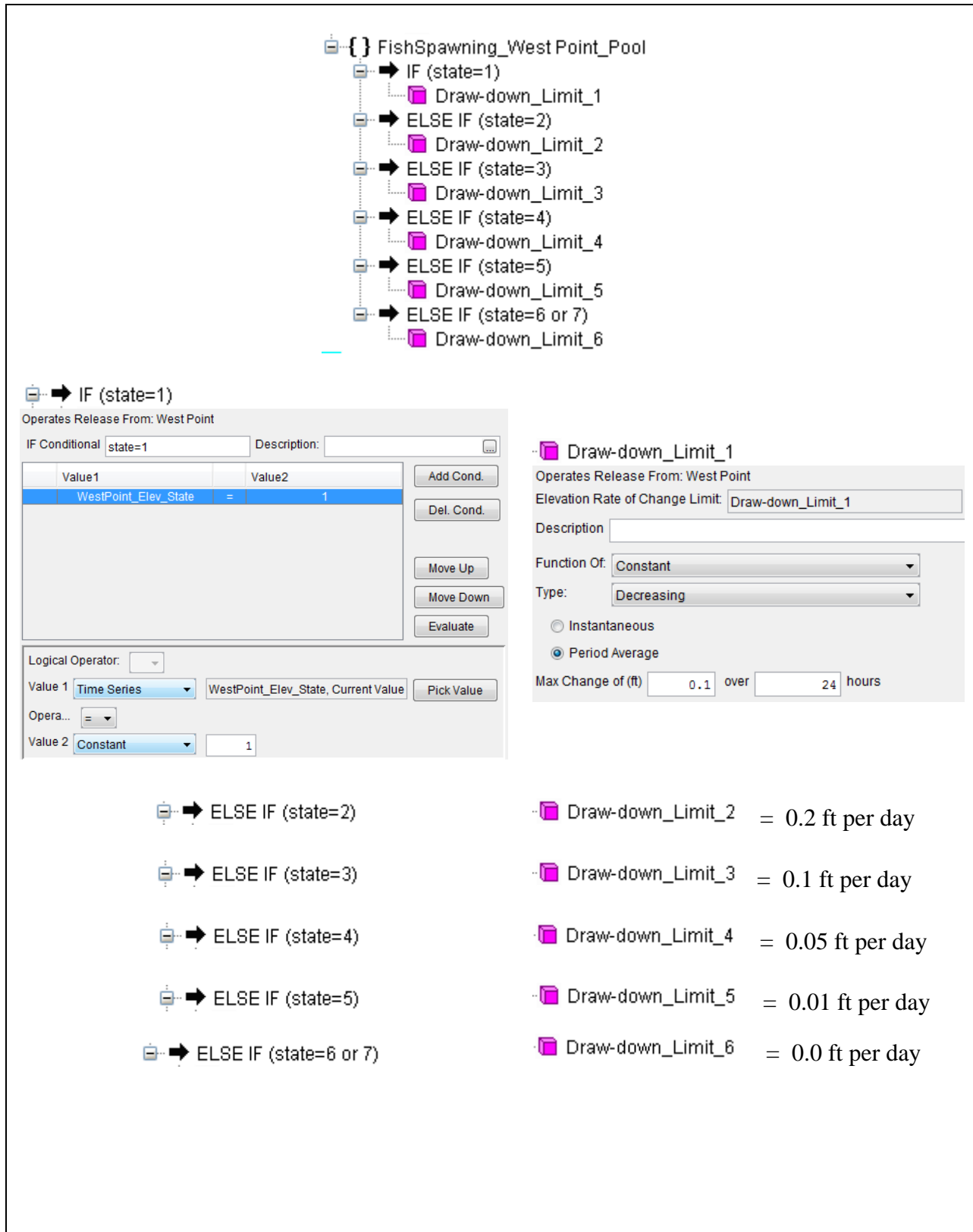


Figure B.12 Fish Spawning -- “IF-Blocks” and “Rules” and “WestPoint_Elev_State” Values

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

Appendix B – West Point

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:

```
5 # State variable: WestPoint_Elev_State
6 # Code=0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #  =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #  =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #  =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #  =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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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									

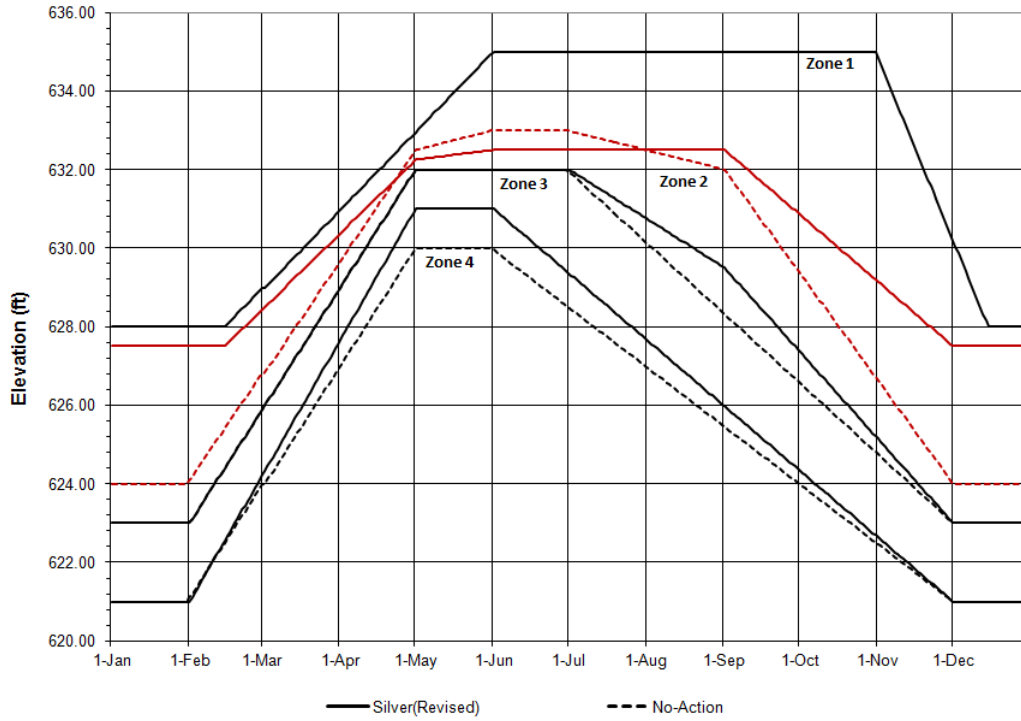


Figure B.13 Comparison of NO-Action and Revised Action Zones at West Point

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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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.

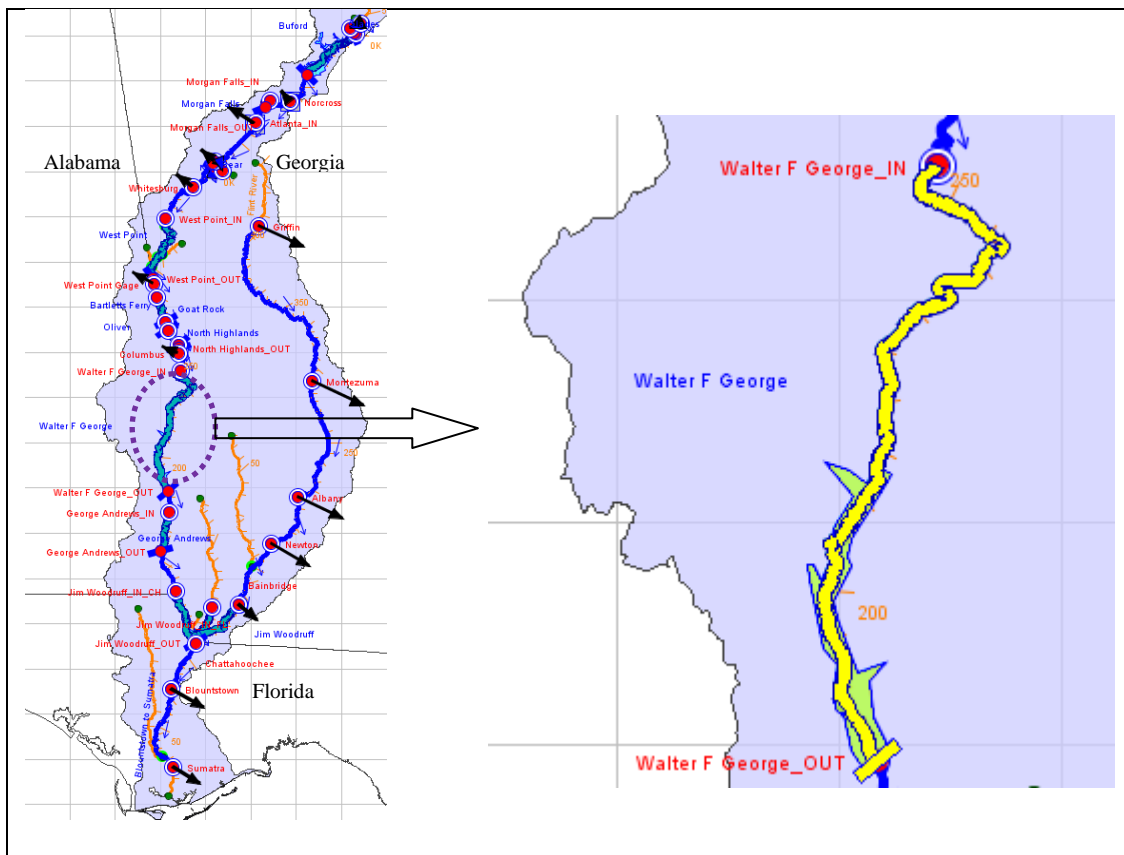


Figure C.01 HEC-ResSim Map Display Showing Location of Walter F. George



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.

Appendix C – Walter F. George

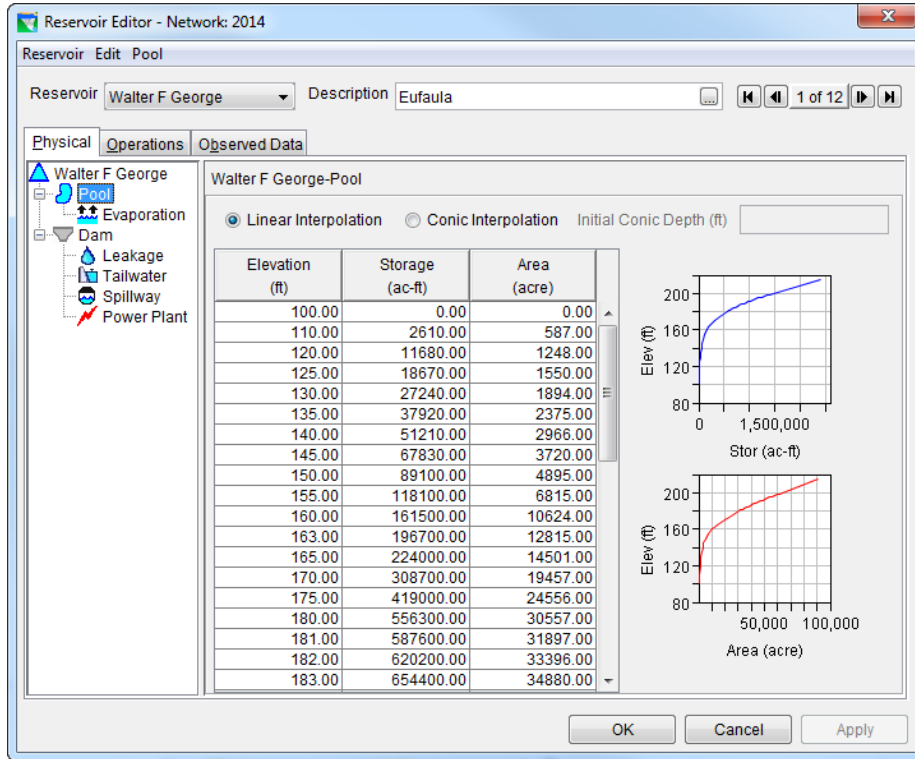


Figure C.03 Reservoir Editor – Network 2014 : Physical Tab -- Pool

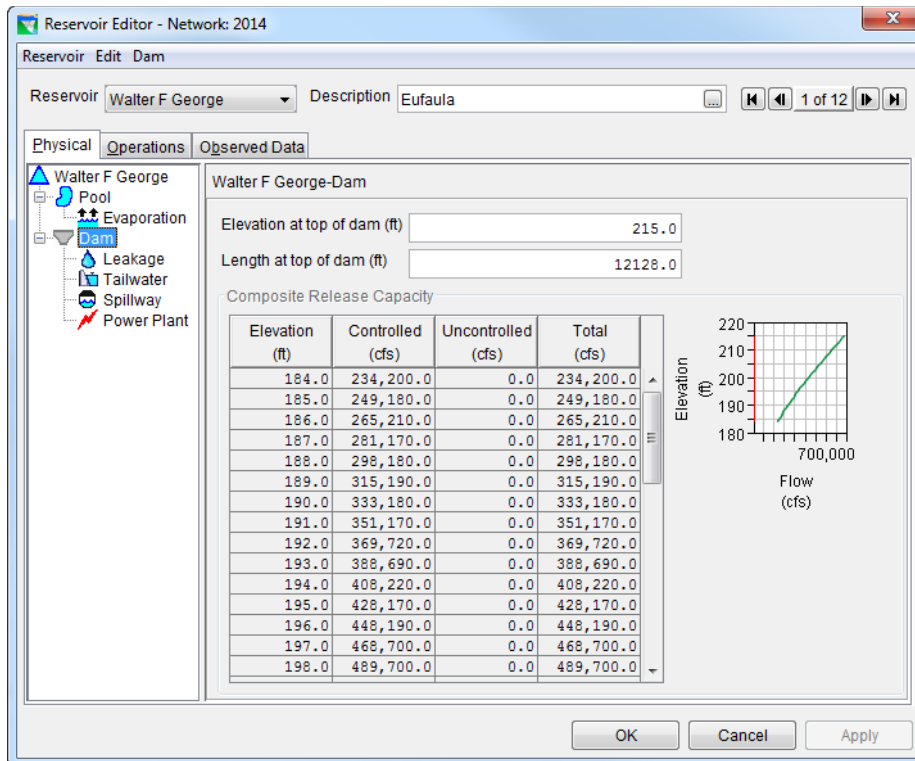


Figure C.04 Reservoir Editor – Network 2014:Physical Tab -- Dam

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 <i>italic</i> values = assumed; Orange <i>linear</i> = 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	<i>linear</i>	188
Zone 2	187.5	187.5	187.5	187.5	189	189	<i>linear</i>	187.5	187.5	187.5
Zone 3	185.5	185.5	186.3	187.1	188	188	<i>linear</i>	<i>linear</i>	<i>linear</i>	185.5
Zone 4	184.5	184.5	<i>linear</i>	187	<i>linear</i>	<i>linear</i>	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)

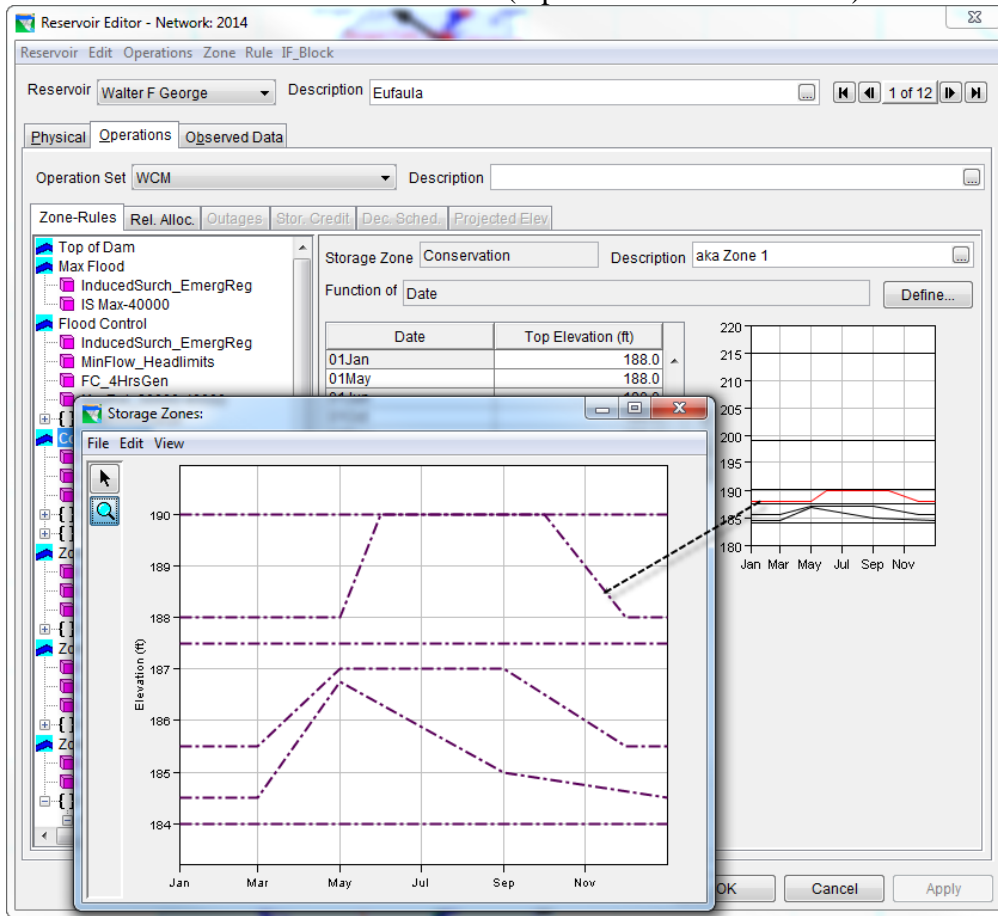


Figure C.05 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

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.

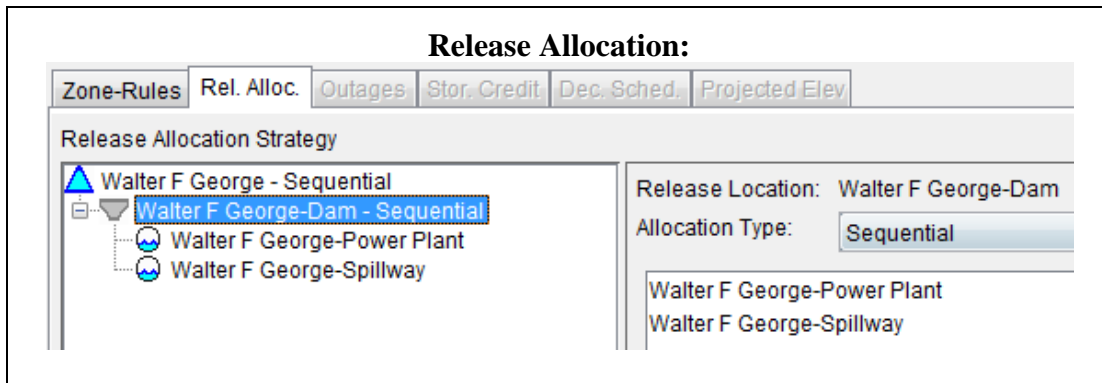
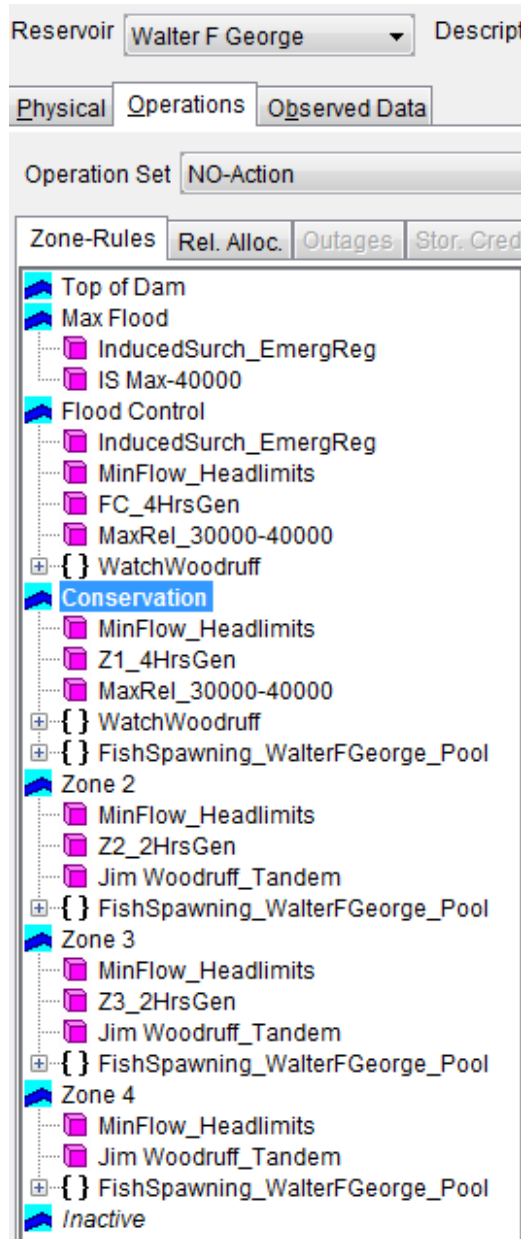


Figure C.06 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

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.

Appendix C – Walter F. George

IS Max-40000

Operates Release From: Walter F George

Rule Name: IS Max-40000 Description: [...]

Function of: Date Define...

Limit Type: Maximum Interp.: Linear

Date	Release (cfs)
01Jan	40000.0

Release (cfs) vs. Month (Jan to Nov) graph showing a constant line at 40,000 cfs.

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

MinFlow_Headlimits

Operates Release From: Walter F George-Dam

Rule Name: MinFlow_Headlimits Description: [...]

Function of: WalterFGeorge_MinTailwater, Current Value Define...

Limit Type: Minimum Interp.: Linear

Elev (ft)	Release (cfs)
101.9	0.0
102.0	4000.0
103.0	6000.0
104.0	7500.0
105.0	8800.0
106.0	10500.0
107.0	12000.0
108.0	14250.0
109.0	15500.0
110.0	17000.0
111.0	18500.0
112.0	20000.0
113.0	21500.0
114.0	23500.0

Release (cfs) vs. Elev (ft) graph showing a linear increase from 0 cfs at 101.9 ft to 23,500 cfs at 114 ft.

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

MaxRel_30000-40000

Operates Release From: Walter F George

Rule Name: MaxRel_30000-40000 Description: [...]

Function of: Walter F George-Pool Elevation, Previous Value Define...

Limit Type: Maximum Interp.: Step

Elev (ft)	Release (cfs)
100.0	30000.0
189.01	40000.0
200.0	40000.0

Release (cfs) vs. Elev (ft) graph showing a step function: 30,000 cfs up to 100 ft, 40,000 cfs up to 189.01 ft, and 40,000 cfs up to 200 ft.

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Jim Woodruff_Tandem

Operates Release From: Walter F George

Tandem Operation Rule: Jim Woodruff_Tandem Description: [...]

Downstream Reservoir: Jim Woodruff

Operates Release From: Walter F George

Name: WatchWoodruff Description: If statement to activate tandem oper[...]

Type	Name	Description
IF	If Woodruff in Zone 1	

Operates Release From: Walter F George

IF Conditional: If Woodruff in Zone 1 Description: [...]

Value1	Value2	Operator
Jim Woodruff-Pool.Elevation	Jim Woodruff-Zone 1.Zone Elevation	<=

Logical Operator: [...]

Value 1: Time Series Jim Woodruff-Pool.Elevation, Previous Value Pick Value

Operator: <=

Value 2: Time Series Jim Woodruff-Zone 1.Zone Elevation, Current Value Pick Value

WatchWoodruff

IF (If Woodruff in Zone 1)

Jim Woodruff_Tandem

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

InducedSurch_EmergReg
 Operates Release From: Walter F George
 Induced Surcharge Rule: **InducedSurch_EmergReg** Description:

Use Induced Surcharge Function Specify the ESRD Curves

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

Specify Releases with Respect to:
 Reservoir Inflow Rate of Rise

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs):

Falling Pool Transition Elev (ft):

Release Options

Ratio of Inflow
Release times Inflow averaged over hours

Avg of Inflow and Previous Release
Inflow averaged over hours

Maintain Peak Release

Maintain Peak Gate Openings

Specify Inflows for ESRD Curves

Reservoir Inflow (cfs)	
1	50000.0
2	100000.0
3	150000.0
4	200000.0
5	250000.0
6	300000.0
7	350000.0
8	400000.0
9	450000.0
10	500000.0
11	550000.0
12	600000.0
13	650000.0
14	700000.0

Inflow Time Series Options

Function:

Lag (hours):

Period (hours):

ESRD Curves for: Walter F George - InducedSurch_EmergReg

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

Appendix C – Walter F. George

FC_4HrsGen (within Flood Control zone)

Operates Release From: Walter F. George-Power Plant
 Hydropower - Power Guide Curve Rule: FC_4HrsGen
 Description: 4 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	16.67
100.0	16.67

Power Generation Pattern...

Z1_4HrsGen (within Conservation zone)

Operates Release From: Walter F. George-Power Plant
 Hydropower - Power Guide Curve Rule: Z1_4HrsGen
 Description: 4 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	16.67
100.0	16.67

Power Generation Pattern...

Z2_2HrsGen (within Zone 2)

Operates Release From: Walter F. George-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	8.33
100.0	8.33

Power Generation Pattern...

Z3_2HrsGen (within Zone 3)

Operates Release From: Walter F. George-Power Plant
 Hydropower - Power Guide Curve Rule: Z3_2HrsGen
 Description: 2 hours of generation at full capacity

Zone at Top of Power Pool: Zone 3
 Zone at Bottom of Power Pool: Zone 4

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

Power Generation Pattern...

**Power Generation Pattern -- Weekdays and Weekend
(for all Hydropower rules shown above)**

Power Generation Pattern

Seasonal Variation Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

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

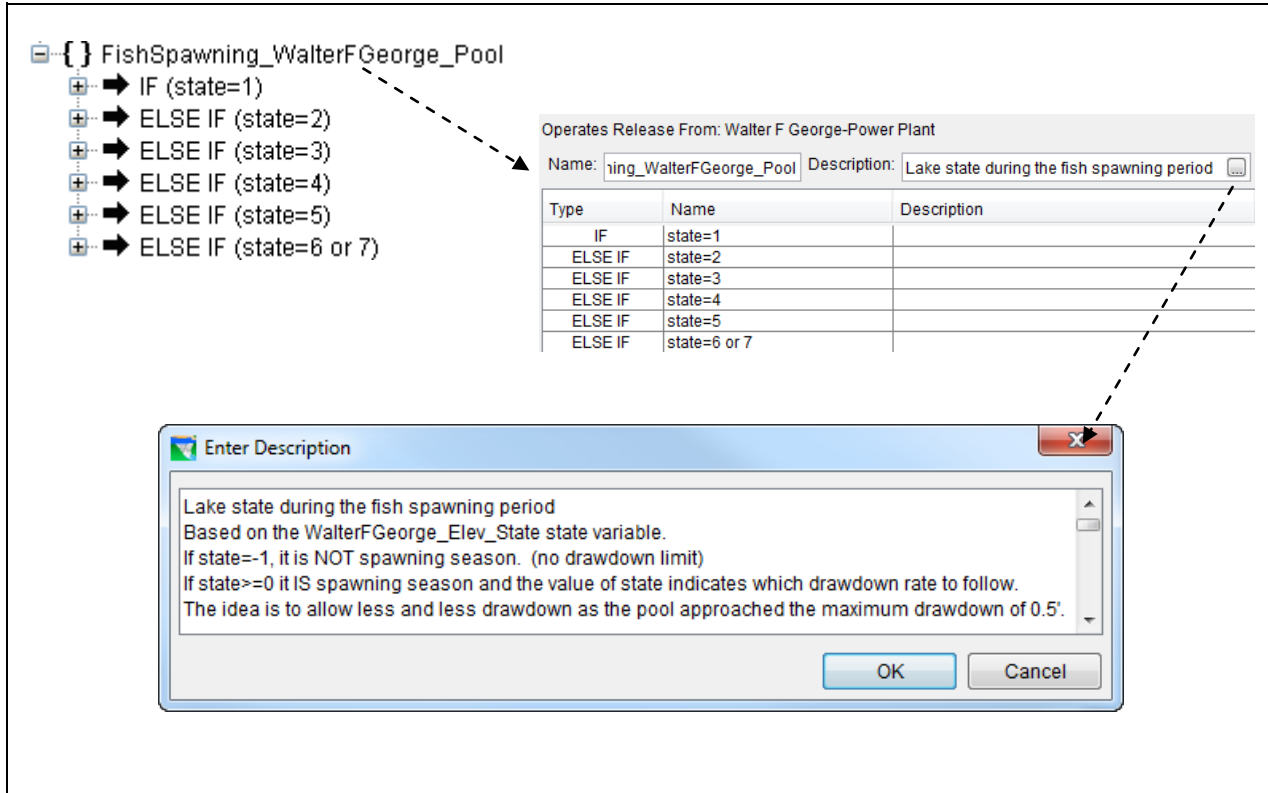


Figure C.11 Fish Spawning -- “Conditional Blocks”

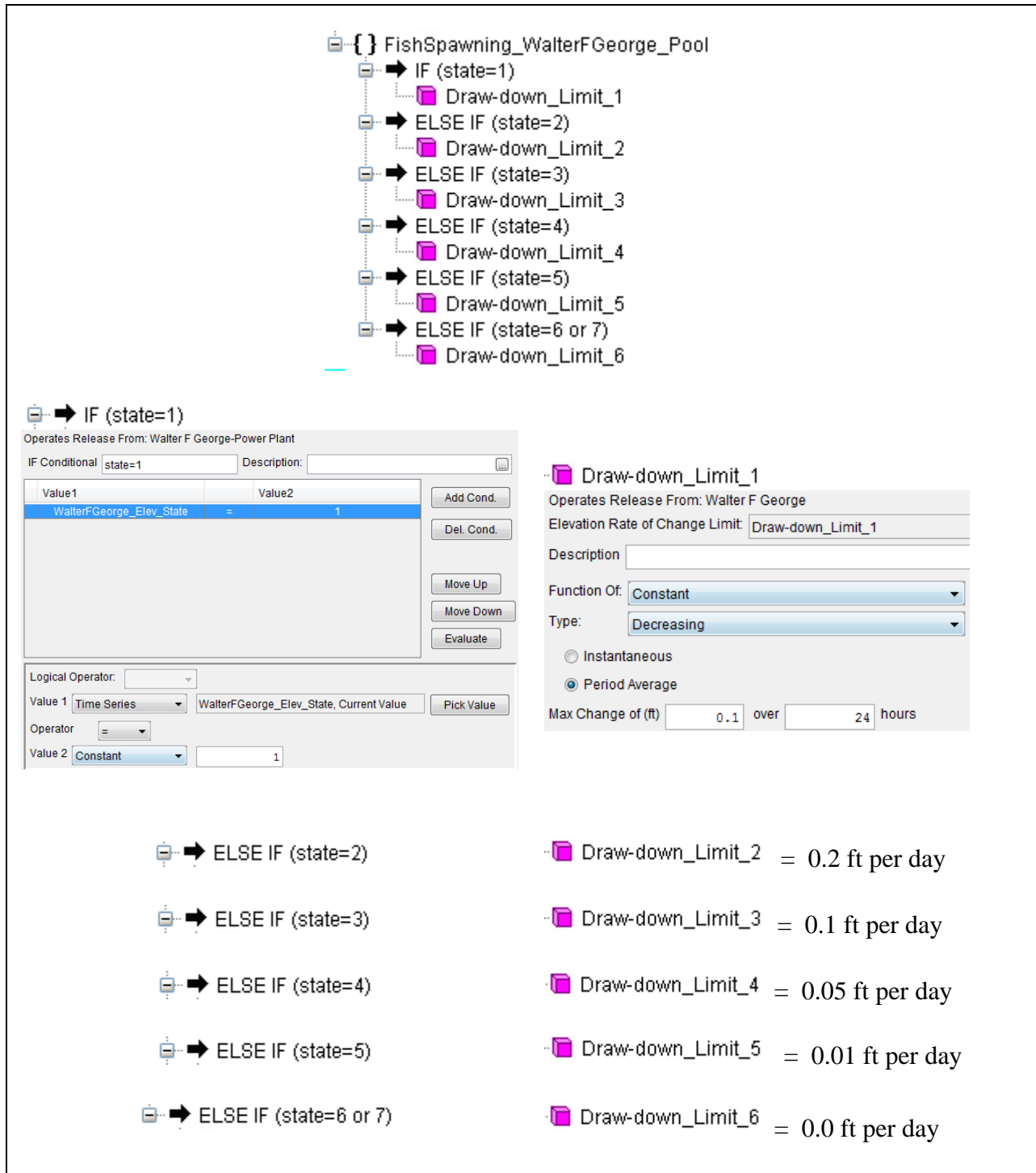


Figure C.12 Fish Spawning -- “IF-Blocks” and “Rules” and “WalterFGeorge_Elev_State” Values

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, “WFGGeorge_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*

Appendix C – Walter F. George

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:

```
5 # State variable: WalterFGeorge_Elev_State
6 # Code =0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #  =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #  =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #  =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #  =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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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						

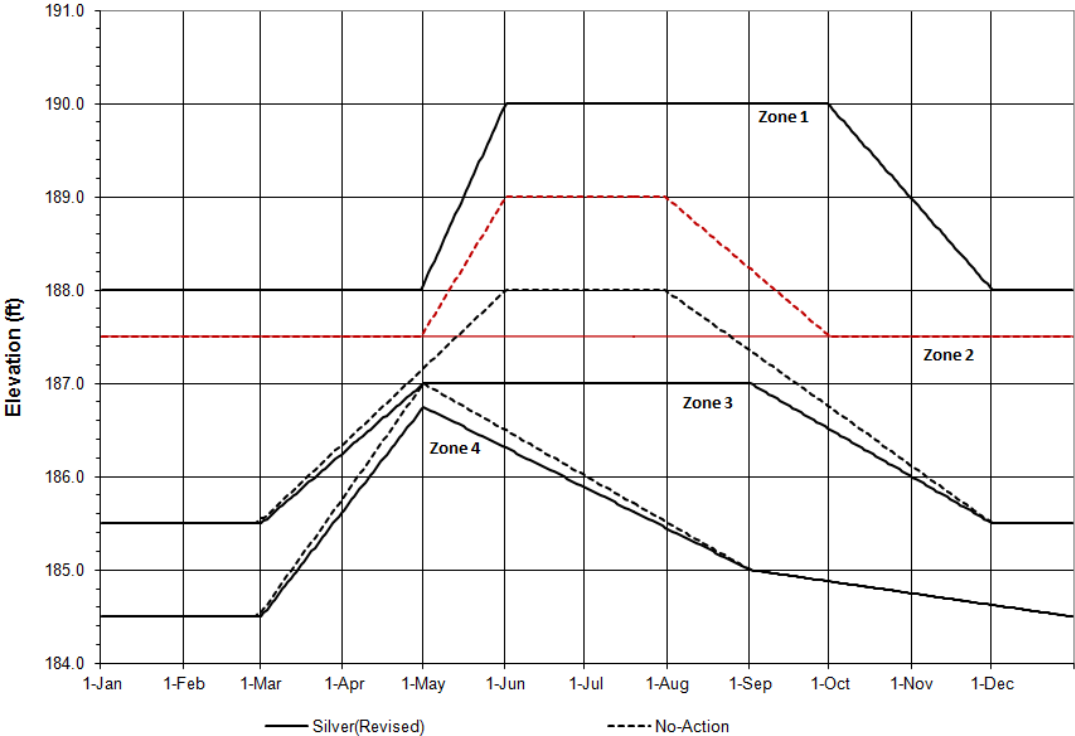


Figure C.13 Comparison of NO-Action and Revised Action Zones at Walter F. George

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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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.

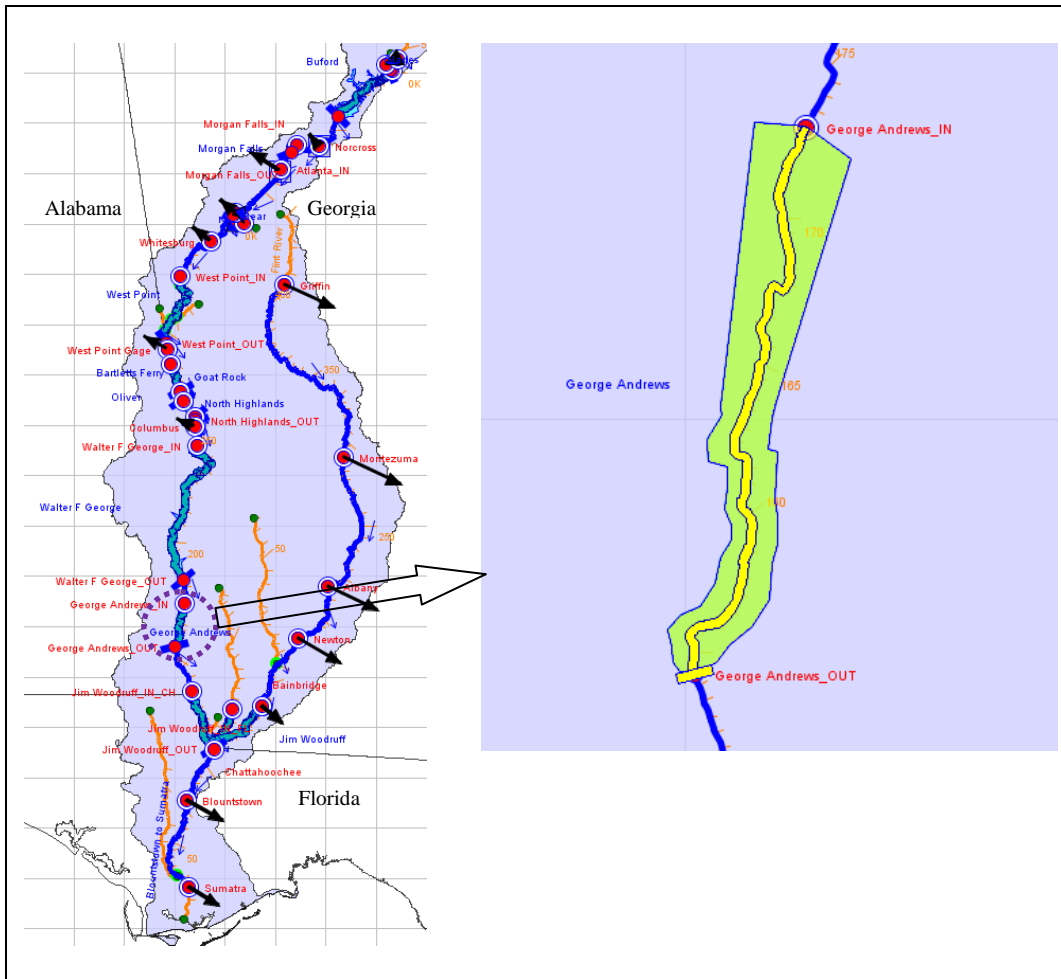


Figure D.01 HEC-ResSim Map Display Showing Location of George Andrews

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).

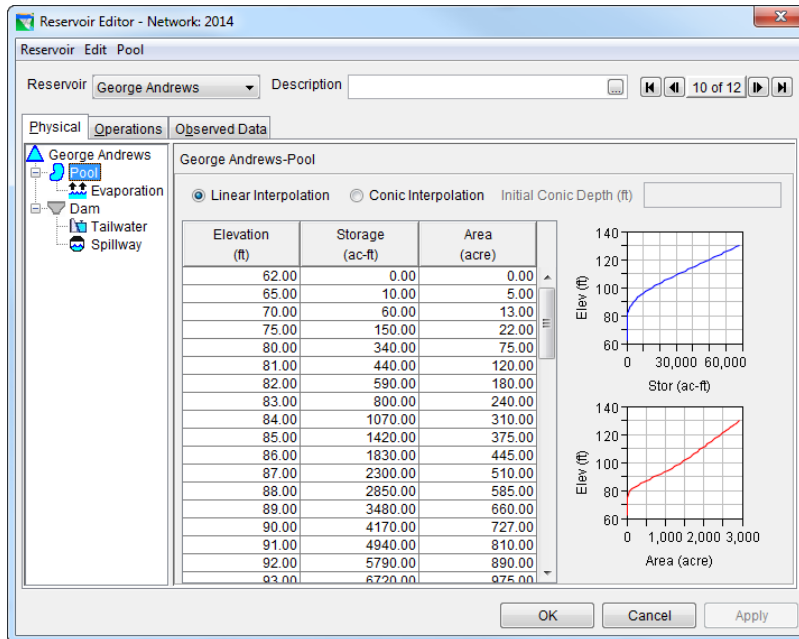


Figure D.03 Reservoir Editor – Network 2014:
Physical Tab -- Pool

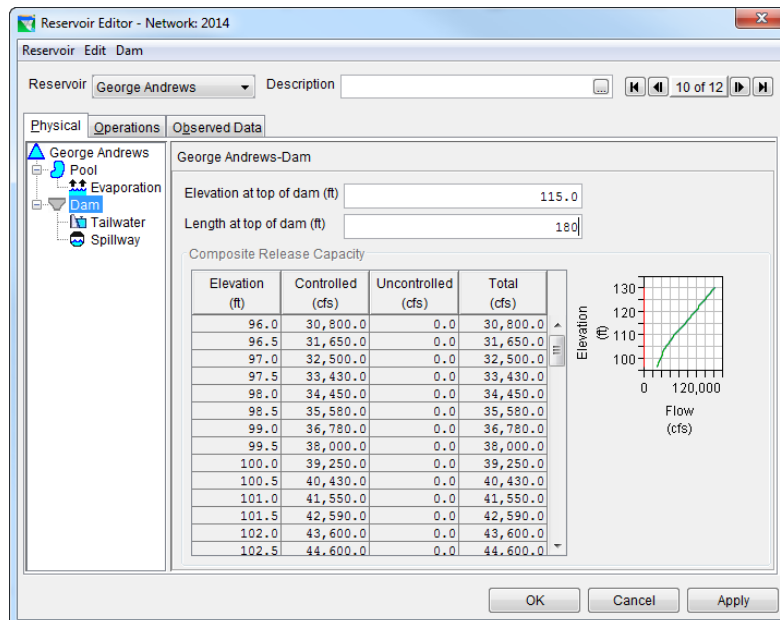


Figure D.04 Reservoir Editor – Network 2014:
Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
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-through* project without any operation rules. It essentially passes inflows.

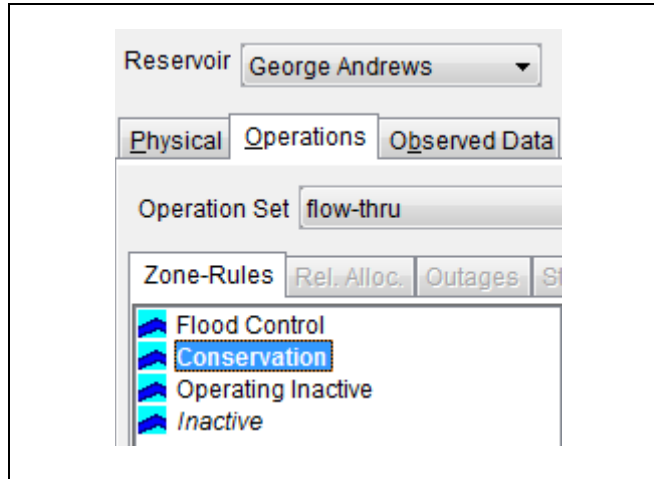


Figure D.05 Operations Tab – Flow-thru Zones

Guide Curve definition (top of Conservation zone)

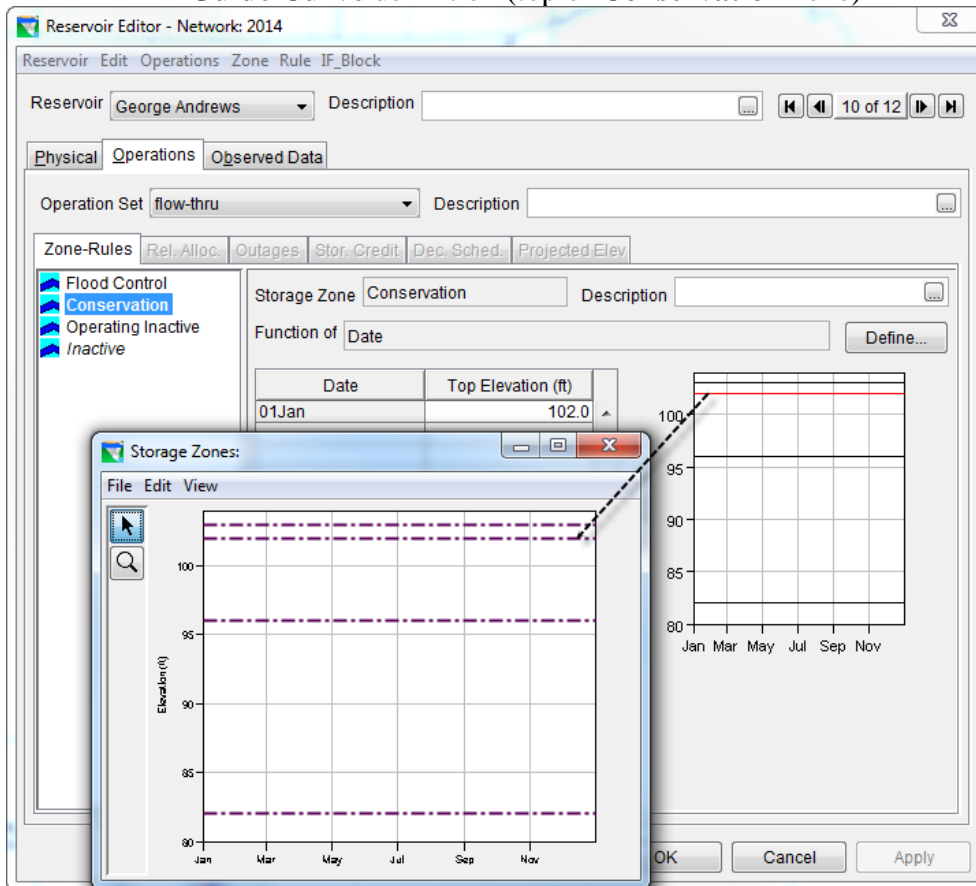


Figure D.06 Reservoir Editor: Operations Tab – Flow-thru OpSet – Guide Curve

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Appendix E – Jim Woodruff

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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.

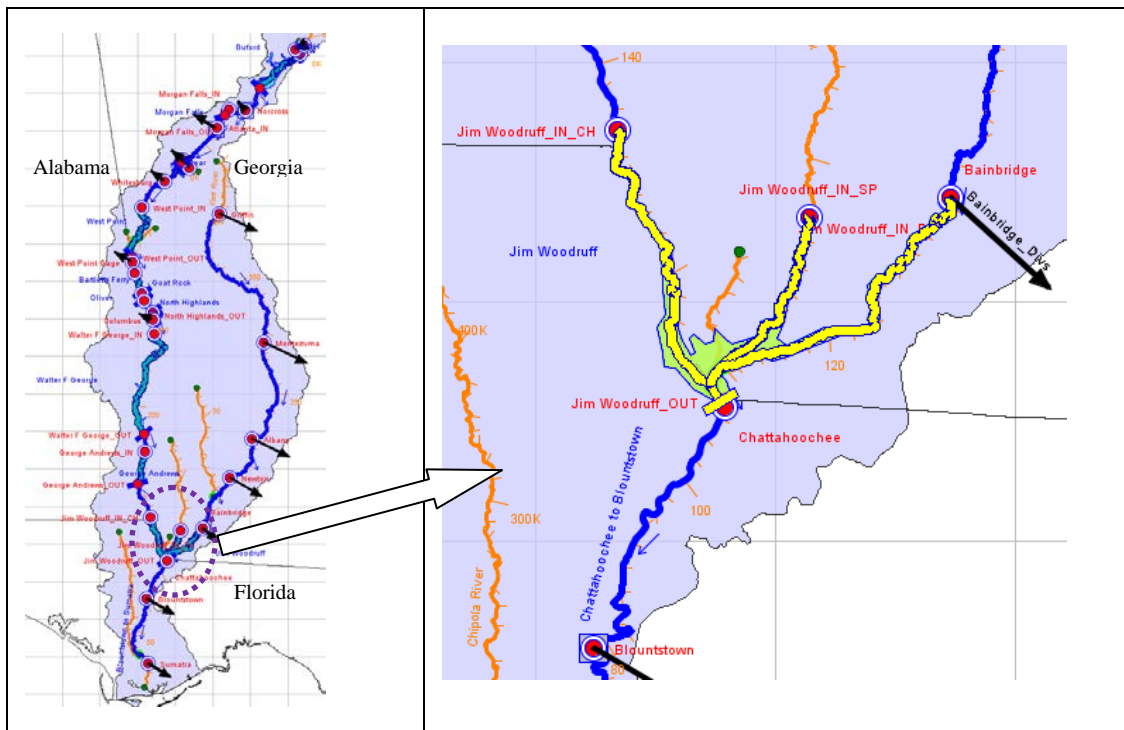


Figure E.01 HEC-ResSim Map Display Showing Location of Jim Woodruff



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.

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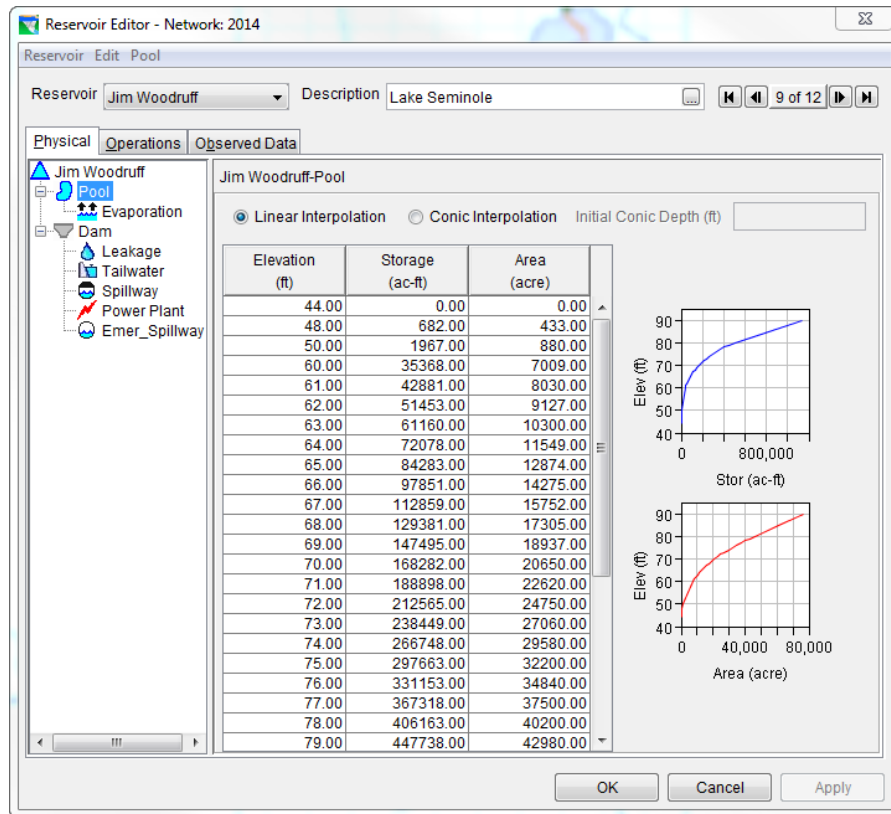


Figure E.03 Reservoir Editor- Network 2014:Physical Tab -- pool

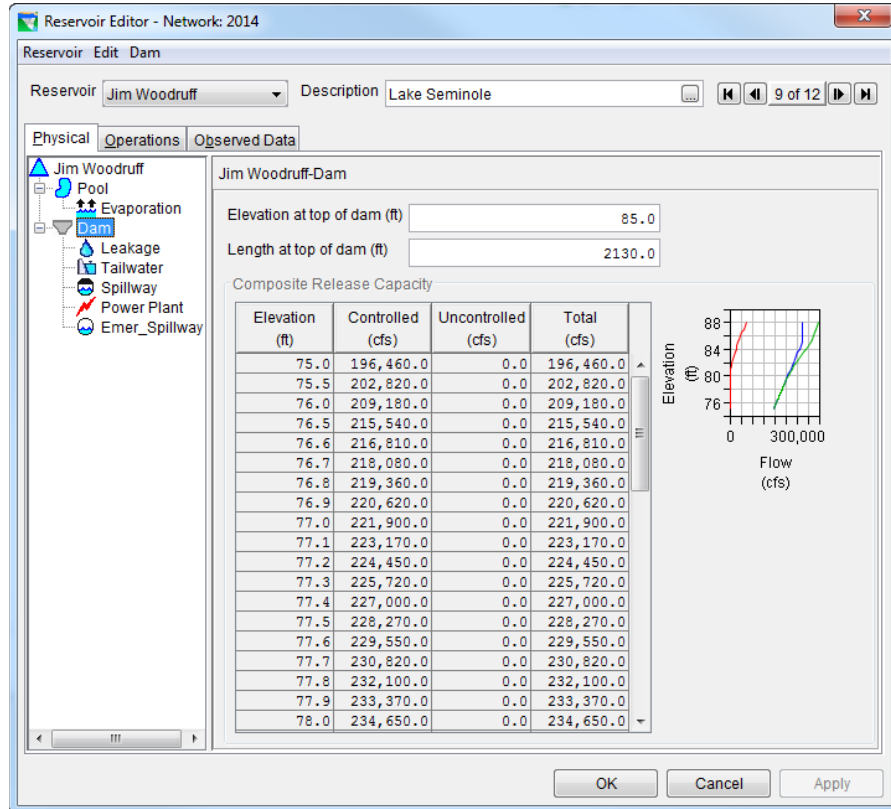


Figure E.04 Reservoir Editor- Network 2014:Physical Tab -- Dam

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 <i>italic</i> values = assumed; Orange <i>linear</i> = linear-interpolated values				
Seasons = Zones	1-Jan	28-Feb	1-Mar	1-Jun	2-Jun
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)

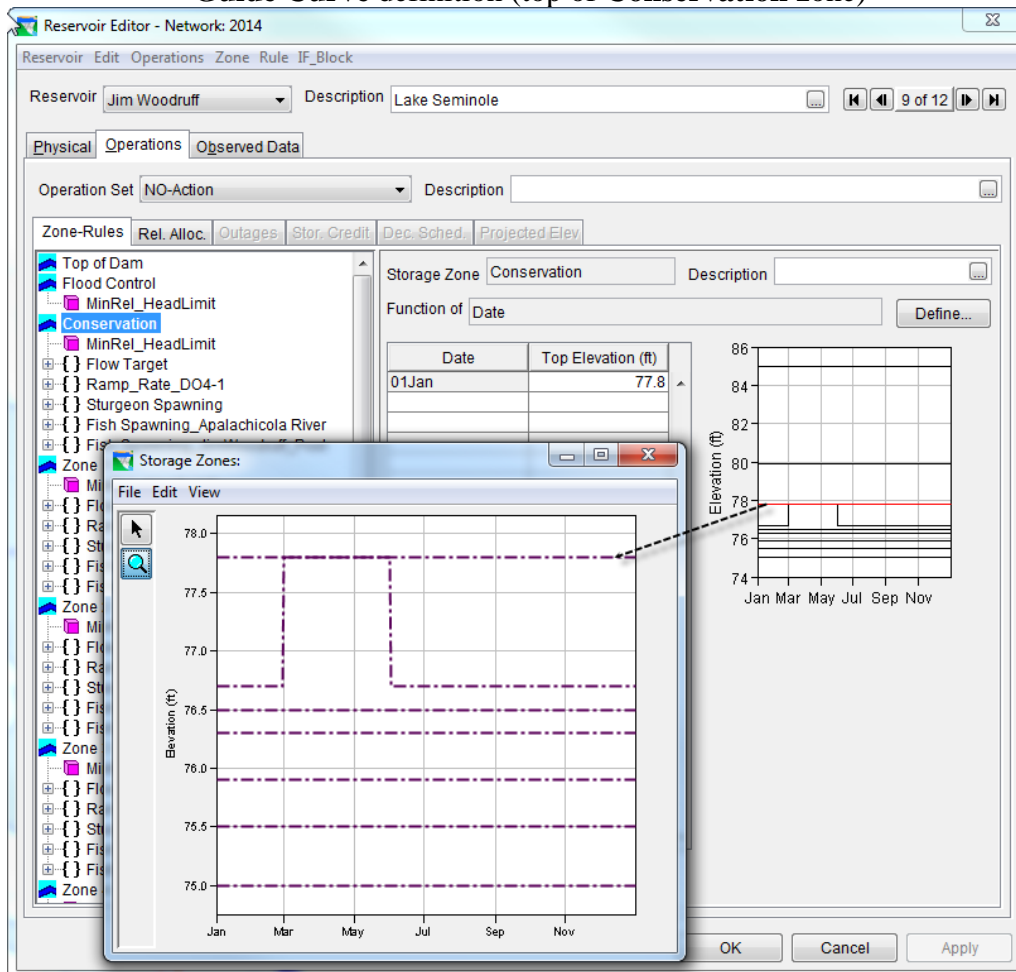


Figure E.05 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Guide Curve

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.

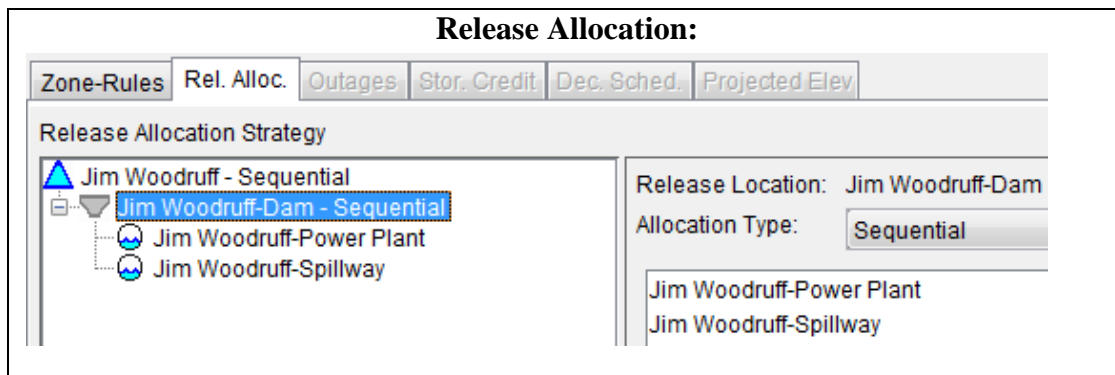


Figure E.06 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Release Allocation

B. Rule Illustrations

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

Reservoir: Jim Woodruff

Physical | Operations | Observed Data

Operation Set: NO-Action

Zone-Rules | Rel. Alloc. | Outages | Stor. Credit

- Top of Dam
 - Flood Control
 - MinRel_HeadLimit
 - Conservation
 - MinRel_HeadLimit
 - Flow Target
 - Ramp_Rate_DO4-1
 - Sturgeon Spawning
 - Fish Spawning_Apalachicola River
 - Fish Spawning_JimWoodruff_Pool
 - Zone 1
 - MinRel_HeadLimit
 - Flow Target
 - Ramp_Rate_DO4-1
 - Sturgeon Spawning
 - Fish Spawning_Apalachicola River
 - Fish Spawning_JimWoodruff_Pool
 - Zone 2
 - MinRel_HeadLimit
 - Flow Target
 - Ramp_Rate_DO4-1
 - Sturgeon Spawning
 - Fish Spawning_Apalachicola River
 - Fish Spawning_JimWoodruff_Pool
 - Zone 3
 - MinRel_HeadLimit
 - Flow Target
 - Ramp_Rate_DO4-1
 - Sturgeon Spawning
 - Fish Spawning_Apalachicola River
 - Fish Spawning_JimWoodruff_Pool
 - Zone 4
 - MinRel_HeadLimit
 - Flow Target
 - Ramp_Rate_DO4-1
 - Sturgeon Spawning
 - Fish Spawning_Apalachicola River
 - Fish Spawning_JimWoodruff_Pool
 - Operating Inactive
 - Release Inflow up to Minimum Reqmt
 - Inactive

MinRel_HeadLimit

Operates Release From: Jim Woodruff

Rule Name: MinRel_HeadLimit | Description: Minimum release based on head

Function of: JimWoodruff_MinTailwater, Current Value

Limit Type: Minimum | Interp.: Linear

Elev (ft)	Release (cfs)
37.5	2850.0
38.0	3500.0
38.5	4180.0
39.0	4900.0
39.5	5670.0
40.0	6480.0
40.5	7320.0
41.0	8200.0
41.5	9120.0
42.0	10100.0
42.5	11000.0
43.0	12100.0
43.5	13100.0
44.0	14200.0
44.5	15300.0
45.0	16400.0
45.5	17500.0

Graph: Release (cfs) vs Elev (ft)

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

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.

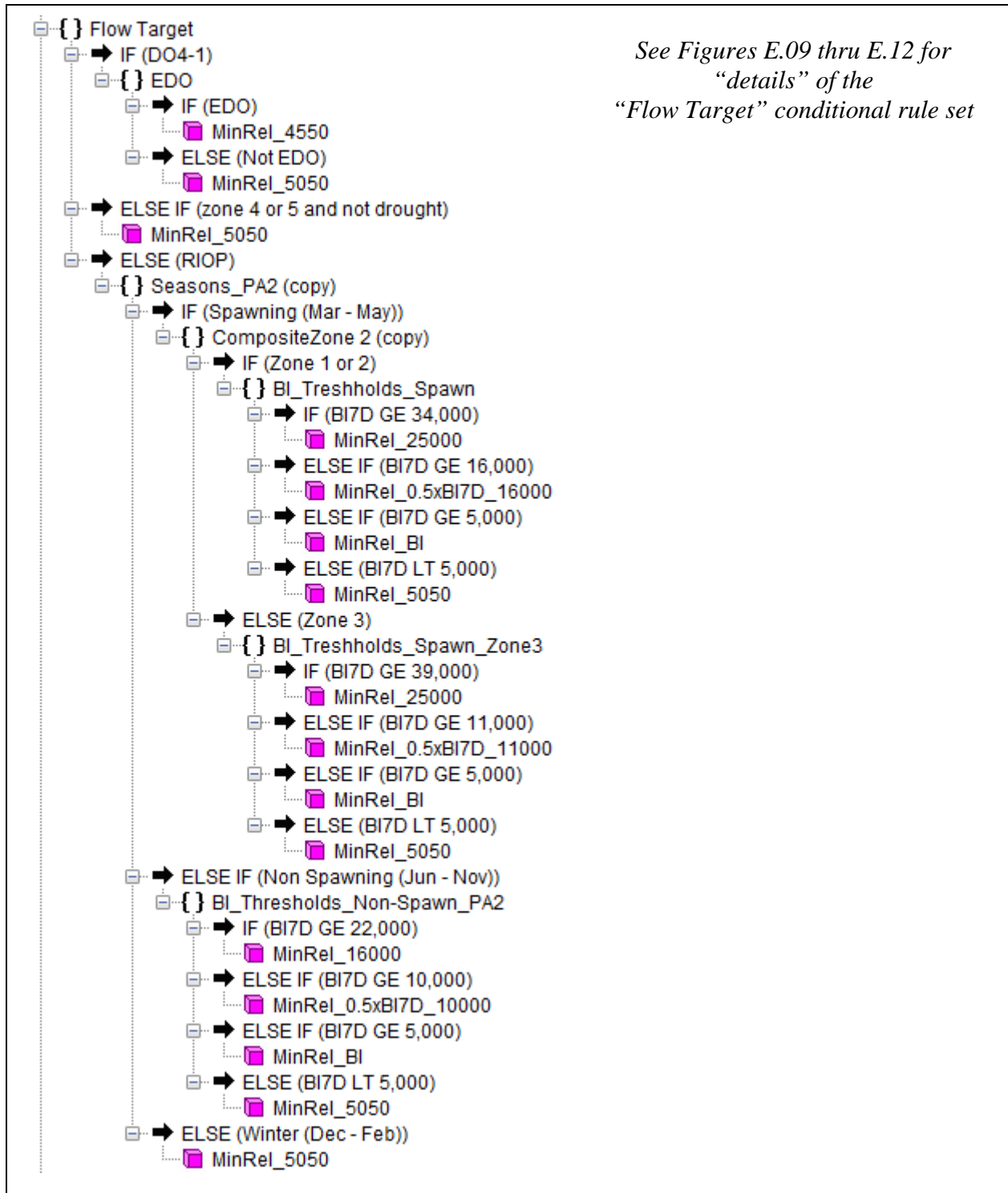


Figure E.08 NO-Action OpSet – Flow Target Conditional Rule Set

Name: Flow Target Description:

Type	Name	Description
IF	DO4-1	
ELSE IF	zone 4 or 5 and not drought	RIOP in Zone 4 or 5, since Drought Ops only set at BOM.
ELSE	RIOP	

IF Conditional DO4-1 Description:

Value1	Value2
Drought_Ops_4_1	= 1

Logical Operator:
 Value 1 Time Series Drought_Ops_4_1, Current Value
 Operator =
 Value 2 Constant 1

ELSE IF Conditional one 4 or 5 and not drought Description: RIOP in Zone 4 or 5, since Drought

Value1	Value2
CompositeStorage	>= 4

Logical Operator:
 Value 1 Time Series CompositeStorage, Current Value
 Operator >=
 Value 2 Constant 4

ELSE Conditional RIOP Description:

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)”

The screenshot displays a complex configuration interface for flow target operations. On the left, a hierarchical tree structure shows the logic flow: a 'Flow Target' containing an 'IF (DO4-1)' block, which leads to an 'EDO' block. This 'EDO' block contains an 'IF (EDO)' block with 'MinRel_4550' and 'ELSE (Not EDO)' with 'MinRel_5050', followed by an 'ELSE IF (zone 4 or 5 and not drought)' block with 'MinRel_5050'. Below this tree, an 'IF Conditional' dialog shows the condition 'EDO_Flow = 1'. To the right, three rule configuration panels are shown: 'EDO', 'MinRel_4550', and 'MinRel_5050'. Each panel includes a table for release values over time and a graph showing a constant release rate.

IF Conditional

Value1	Value2
EDO_Flow	1

Logical Operator: [v]
 Value 1: Time Series [v] EDO_Flow, Current Value [v] Pick Value
 Operator: [=]
 Value 2: Constant [v] 1

EDO Rule Configuration

Type	Name	Description
IF	EDO	
ELSE	Not EDO	

Operates Release From: Jim Woodruff
 Rule Name: MinRel_4550
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	4550.0

MinRel_5050 Rule Configuration

Operates Release From: Jim Woodruff
 Rule Name: MinRel_5050
 Description: This flow of 5050 cfs represents the r...
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	5050.0

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

The screenshot displays a complex logic tree on the left and three configuration panels on the right. The tree starts with a 'Flow Target' containing several conditional blocks. A purple bracket labeled 'See Figure E.12' highlights a section of the tree. The right side shows configuration details for three specific nodes: 'Seasons_PA2', 'CompositeZone 2', and 'Zone 3'. Each configuration panel includes a table of conditions, logical operators, and value selectors.

Seasons_PA2 Configuration:

Type	Name	Description
IF	Spawning (Mar - May)	Seasons Code = 1
ELSE IF	Non Spawning (Jun - Nov)	Seasons Code = 2
ELSE	Winter (Dec - Feb)	Seasons Code = 3

IF Conditional: Spawning (Mar - May)

Value1	Value2
Seasons	= 1

Logical Operator: [Dropdown]
 Value 1: Time Series (Seasons, Current Value) [Pick Value]
 Operator: =
 Value 2: Constant (1)

CompositeZone 2 Configuration:

Type	Name	Description
IF	Zone 1 or 2	
ELSE	Zone 3	No check for zone 4-5 because handled by Drought Operations logic

IF Conditional: Zone 1 or 2

Value1	Value2
CompositeStorage	<= 2

Logical Operator: [Dropdown]
 Value 1: Time Series (CompositeStorage, Current Value) [Pick Value]
 Operator: <=
 Value 2: Constant (2)

ELSE Conditional: Zone 3

Description: No check for zone 4-5 because handled by Drought Operations logic

Enter Description Dialog:

No check for zone 4-5 because handled by Drought Operations logic

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

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Seasons_PA2

- IF (Spawning (Mar - May))
- ELSE IF (Non Spawning (Jun - Nov))
 - BI_Thresholds_Non-Spawn_PA2**
 - IF (BI7D GE 22,000)
 - MinRel_16000
 - ELSE IF (BI7D GE 10,000)
 - MinRel_0.5xBI7D_10000
 - ELSE IF (BI7D GE 5,000)
 - MinRel_BI
 - ELSE (BI7D LT 5,000)
 - MinRel_5050
 - ELSE (Winter (Dec - Feb))
 - MinRel_5050

BI_Thresholds_Non-Spawn

Type	Name	Description
IF	BI7D GE 22,000	
ELSE IF	BI7D GE 10,000	
ELSE IF	BI7D GE 5,000	
ELSE	BI7D LT 5,000	

BI_Thresholds_Non-Spawn_PA2

- IF (BI7D GE 22,000)
 - MinRel_16000
- ELSE IF (BI7D GE 10,000)
 - MinRel_0.5xBI7D_10000
- ELSE IF (BI7D GE 5,000)
 - MinRel_BI
- ELSE (BI7D LT 5,000)
 - MinRel_5050

MinRel_16000

Operates Release From: Jim Woodruff
 Rule Name: MinRel_16000
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	16000.0

MinRel_0.5xBI7D_10000

Operates Release From: Jim Woodruff
 Rule Name: MinRel_0.5xBI7D_10000 Description: min=10,000 cfs plus 50% of BI7D
 Function of: BI_FMA7, Current Value
 Limit Type: Minimum Interp.: Linear

FLOW (cfs)	Release (cfs)
0.0	10000.0
10000.0	10000.0
22000.0	16000.0

MinRel_BI

Operates Release From: Jim Woodruff
 Rule Name: MinRel_BI
 Function of: BI_FMA7, Current Value
 Limit Type: Minimum Interp.: Linear

FLOW (cfs)	Release (cfs)
0.0	0.0
9999999.0	9999999.0

MinRel_5050

Operates Release From: Jim Woodruff
 Rule Name: MinRel_5050
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	5050.0

ELSE IF Conditional Non Spawning (Jun - Nov) Description: Seasons Code = 2

Value1	Value2
Seasons	= 2

ELSE IF Conditional BI7D GE 22,000

Value 1	Operator	Value 2
Time Series BI_FMA7, Current Value	>=	Constant 22000

ELSE IF Conditional BI7D GE 10,000

Value 1	Operator	Value 2
Time Series BI_FMA7, Current Value	>=	Constant 10000

ELSE IF Conditional BI7D GE 5,000

Value 1	Operator	Value 2
Time Series BI_FMA7, Current Value	>=	Constant 5000

ELSE Conditional BI7D LT 5,000

ELSE Conditional Winter (Dec - Feb) Description: Seasons Code = 3

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

The screenshot displays a logic tree for **Ramp_Rate_DO4-1** on the left, with detailed views of its components on the right. The logic tree includes:

- IF (DO4-1)**
 - Hold_RR**
 - IF (Hold_RR=1)**
 - RIOP-Falling Ramp Rate PA2**
 - ELSE (Hold_RR=0)**
 - BI-Falling Ramp Rate**
 - ELSE IF (zone 4 or 5 and not drought)**
 - FallingRampRate_RIOP 2**
 - IF (Release LE 30000)**
 - RIOP-Falling Ramp Rate PA2**
 - ELSE (RIOP)**
 - FallingRampRate_RIOP 2**
 - IF (Release LE 30000)**
 - RIOP-Falling Ramp Rate PA2**

RIOP-Falling Ramp Rate PA2 details:

- Operates Release From: Jim Woodruff
- Release Rate of Change Limit: RIOP-Falling Ramp Rate PA2
- Description: Ramp Rate data from ' Spreadsheet "Revised_ramping_rate.xls"
- Function Of: Release
- Type: Decreasing
- Interpolate: Linear
- Table:

Release (cfs)	Rate Change (cfs/hr)
1000.0	6.417
2000.0	6.792
3000.0	7.167
4000.0	7.542
5000.0	7.908
6000.0	8.311
7000.0	8.713
8000.0	9.115
9000.0	9.533
10000.0	19.167
11000.0	27.52

BI-Falling Ramp Rate details:

- Operates Release From: Jim Woodruff
- Rule Name: BI-Falling Ramp Rate
- Function of: BIFallRate, Current Value
- Limit Type: Minimum
- Interp.: Linear
- Table:

Flow-Diff (cfs)	Release (cfs)
0.0	0.0
30000.0	30000.0

Hold_RR configuration:

- Name: Hold_RR
- Description:
- Table:

Type	Name	Description
IF	Hold_RR=1	
ELSE	Hold_RR=0	

IF Conditional Hold_RR=1 configuration:

- Name: IF Conditional Hold_RR=1
- Description:
- Table:

Value1	Value2
Hold_RR	1
- Logical Operator: =
- Value 1: Time Series, Hold_RR, Current Value
- Operat...: =
- Value 2: Constant, 1

ELSE Conditional Hold_RR=0 configuration:

- Name: ELSE Conditional Hold_RR=0
- Description:
- Table:

Type	Name	Description
IF	Release LE 30000	

IF Conditional Release LE 30000 configuration:

- Name: IF Conditional Release LE 30000
- Description:
- Table:

Value1	Value2
Jim Woodruff-Pool:Outflow	30000
- Logical Operator: <=
- Value 1: Time Series, Woodruff-Pool:Outflow, Previous Value
- Operat...: <=
- Value 2: Constant, 30000

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

The screenshot displays three windows from a software interface, likely for water resource modeling. Dashed arrows indicate the relationship between the objects in a tree view on the left and the configuration windows.

Top Window: Operates Release From: Jim Woodruff
 Name: Sturgeon Spawning | Description: []
 Table:

Type	Name	Description
IF	Mar thru May	

Middle Window: Operates Release From: Jim Woodruff
 IF Conditional: Mar thru May | Description: []
 Table:

Value1	Value2
Seasons	= 1

Buttons: Add Cond., Del. Cond., Move Up, Move Down, Evaluate
 Logical Operator: []
 Value 1: Time Series | Seasons, Current Value | Pick Value
 Operator: =
 Value 2: Constant | 1

Bottom Window: MinRel_forSturgeon
 Operates Release From: Jim Woodruff
 Rule Name: MinRel_forSturgeon | Description: []
 Function of: MinStage_Chattahoochee, Current Value | Define...
 Limit Type: Minimum | Interp.: Linear

Elev-Min (ft)	Release (cfs)
35.5	0.0
37.0	1999.0
38.0	3500.0
38.5	4180.0
39.0	4900.0
39.5	5670.0
40.0	6480.0
40.5	7320.0
41.0	8200.0
41.5	9120.0
42.0	10100.0
42.5	11000.0
43.0	12100.0
43.5	13100.0
44.0	14200.0
44.5	15300.0
45.0	16400.0

Graph: Release (cfs) vs Elev-Min (ft). The graph shows a curve starting at (35, 0) and ending at (55, 16400).
 Checkboxes: Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, Seasonal Variation. Each has an Edit... button.

Figure E.14 Sturgeon Spawning -- “Conditional Blocks” and Rule

Operates Release From: Jim Woodruff
 Name: Fish Spawning_Apalachicola River Description: Operational consideration for fish spawning on the Apalachicola River

Type	Name	Description
IF	(01Apr-01Jun) & (flow.LE.30000)	Fish spawning period: 01April - 01June

IF Conditional (01Apr-01Jun) & (flow.LE.30000) Description: Fish spawning period: 01April - 01June

	Value1		Value2
	(
	Current Time Step	>=	01Apr
AND	Current Time Step	<=	01Jun
)		
AND	Jim Woodruff-Pool:Outflow	<=	30000

RiverStage_FallingLimit
 Operates Release From: Jim Woodruff
 Release Rate of Change Limit: RiverStage_FallingLimit
 Description: River stage ramping down of 0.5 foot per day or less. The relation between release and flow rate change were calculated in the spreadsheet, called "FishSpawning_ApalachicolaRiver.xls"

Function Of: Release
 Type: Decreasing
 Interpolate: Linear

Release (cfs)	Rate Change (cfs/hr)
1000.0	28.4
2000.0	28.2
3000.0	28.5
4000.0	28.2
5000.0	30.6
6000.0	33.0
7000.0	34.5
8000.0	36.0
9000.0	38.5
10000.0	40.5
12000.0	45.4
14000.0	45.0
16000.0	45.7
18000.0	47.4
20000.0	50.2
24000.0	53.7
28000.0	58.0
32000.0	59.0
36000.0	61.7
40000.0	65.0

Enter Description
 River stage ramping down of 0.5 foot per day or less. The relation between release and flow rate change were calculated in the spreadsheet, called "FishSpawning_ApalachicolaRiver.xls"

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

Operates Release From: Jim Woodruff

Name: Fish Spawning_JimWoodruff Description: Based on the JimWoodruff_Elev_State

Type	Name	Description
IF	state=1	
ELSE IF	state=2	
ELSE IF	state=3	
ELSE IF	state=4	
ELSE IF	state=5	
ELSE IF	state=6 or 7	

Fish Spawning_JimWoodruff_Pool

- IF (state=1)
- ELSE IF (state=2)
- ELSE IF (state=3)
- ELSE IF (state=4)
- ELSE IF (state=5)
- ELSE IF (state=6 or 7)

Enter Description

Based on the JimWoodruff_Elev_State state variable.
 If state=-1, it is NOT spawning season. (no drawdown limit)
 If state>=0 it IS spawning season and the value of state indicates which drawdown rate to follow.
 The idea is to allow less and less drawdown as the pool approached the maximum drawdown of 0.5'.

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

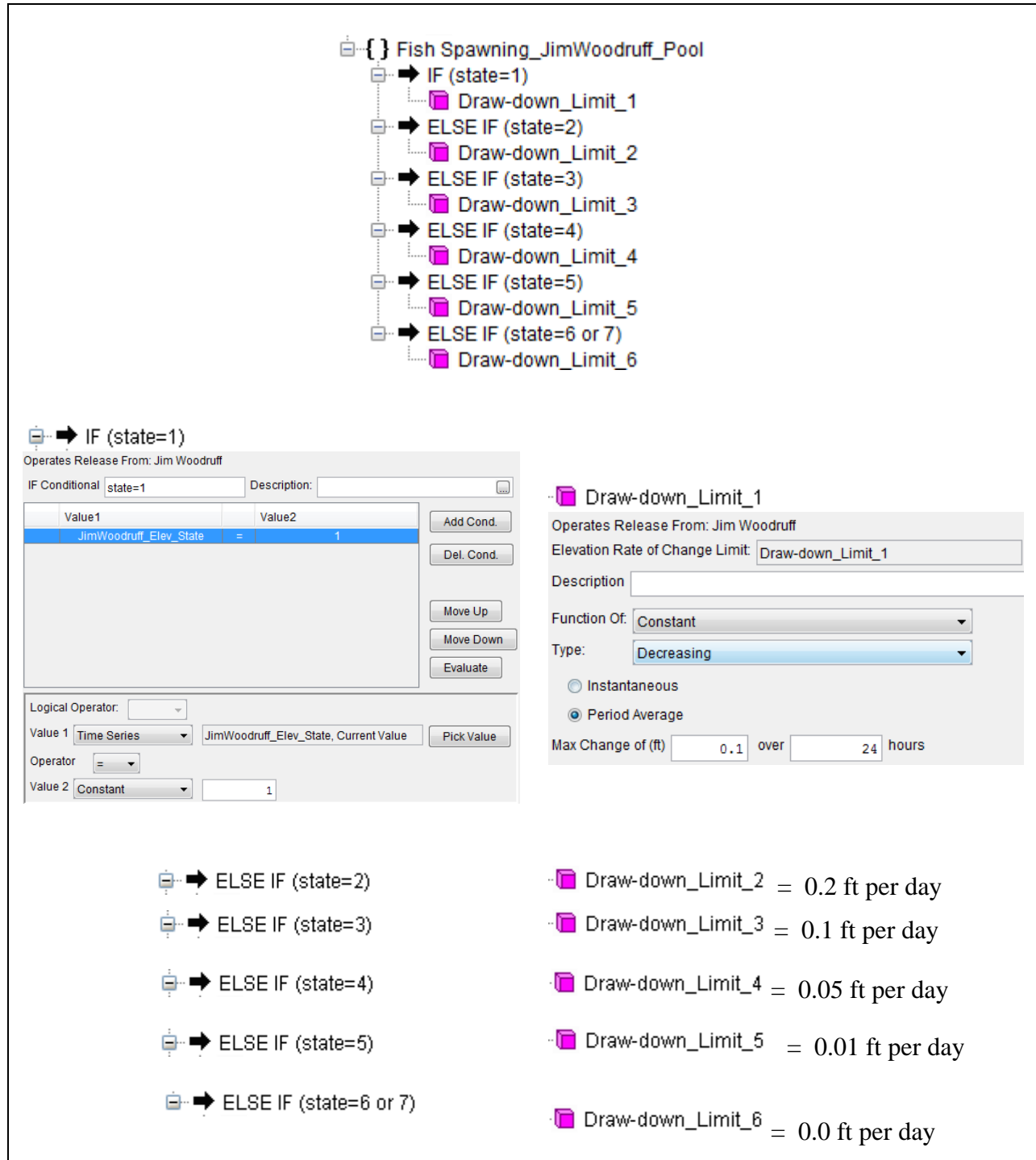


Figure E.17 Fish Spawning at Jim Woodruff -- “IF-Blocks” and “Rules”

{} Release Inflow up to Minimum Reqmt

- Operating Inactive
- {}** Release Inflow up to Minimum Reqmt
 - IF (EDO)
 - MinInflow_to4550
 - ELSE (not EDO)
 - MinInflow_to5050

Operates Release From: Jim Woodruff

Name: Description:

Type	Name	Description
IF	EDO	
ELSE	not EDO	

Operates Release From: Jim Woodruff

IF Conditional: Description:

Value1	Value2
EDO_Flow	= 1

Logical Operator:

Value 1:

Operator:

Value 2:

MinInflow_to4550

Operates Release From: Jim Woodruff

Rule Name: Description:

Function of:

Limit Type: Interp.:

Flow (cfs)	Release (cfs)
0.0	0.0
4550.0	4550.0
1000000.0	4550.0

MinInflow_to5050

Operates Release From: Jim Woodruff

Rule Name: Description:

Function of:

Limit Type: Interp.:

Flow (cfs)	Release (cfs)
0.0	0.0
5050.0	5050.0
1000000.0	5050.0

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

E-20

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.

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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)
$\geq 34,000$	25,000
$\geq 16,000$ and $< 34,000$	$16,000 + 50\%$ of BI
$\geq 5,000$ 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)
$\geq 22,000$	16,000
$\geq 10,000$ and $< 22,000$	$10,000 + 50\%$ of BI
$\geq 5,000$ 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_D04-1

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

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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:

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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

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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:

```

5 # State variable: JimWoodruff_Elev_State
6 # Code =0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #  =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #  =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #  =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #  =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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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”.

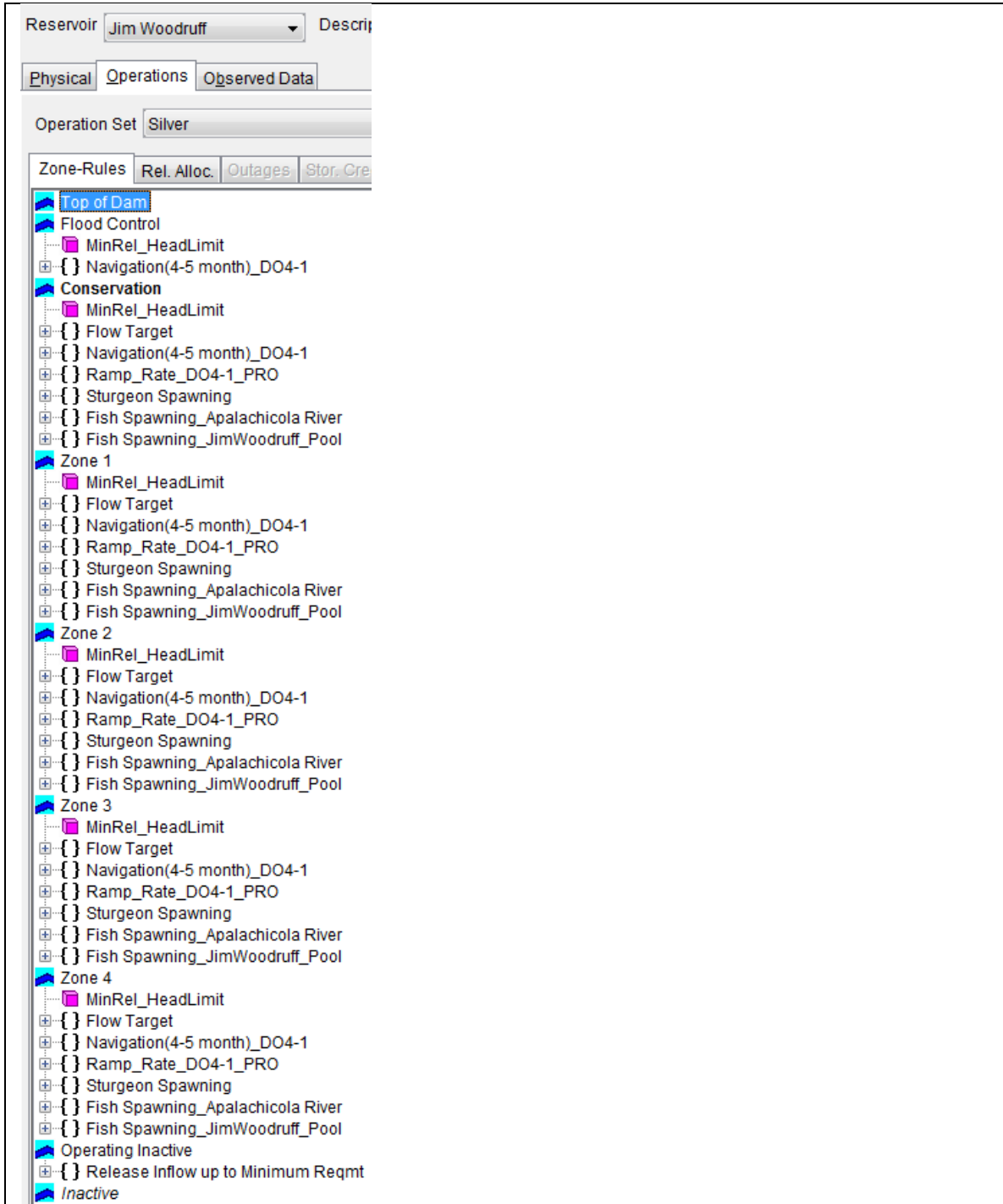


Figure E.19 Reservoir Editor- Network 2014: Operations Tab – Silver OpSet – Zones and Rules

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.

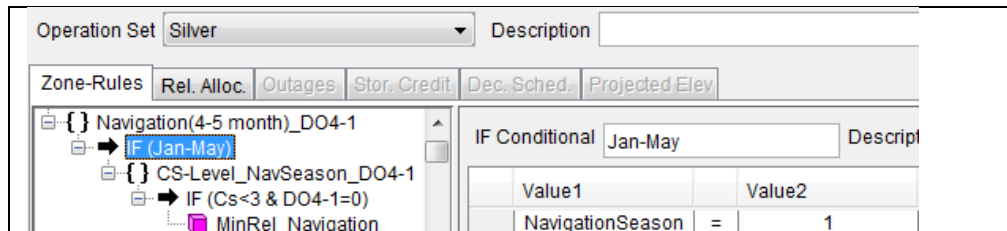


Figure E.20 Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

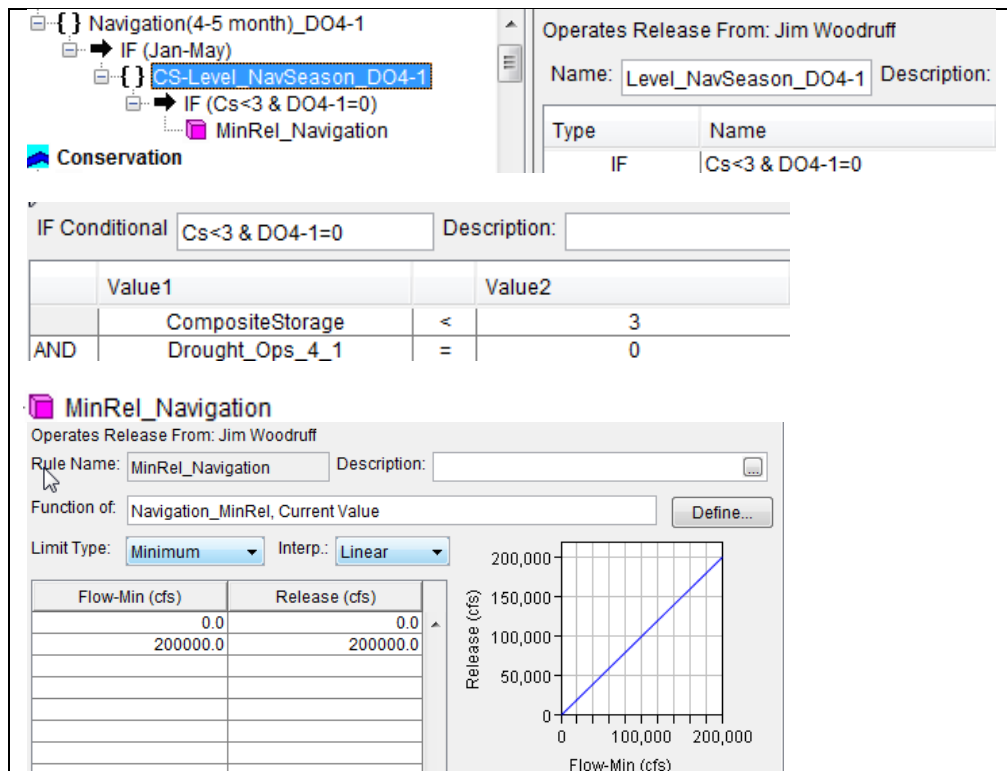


Figure E.21 Release Rules for *Navigation(4-5 month)_DO4-1* Rule

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 *ProlongedLowFlow* shown in Figure E.22 described in Appendix H. 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. 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*.

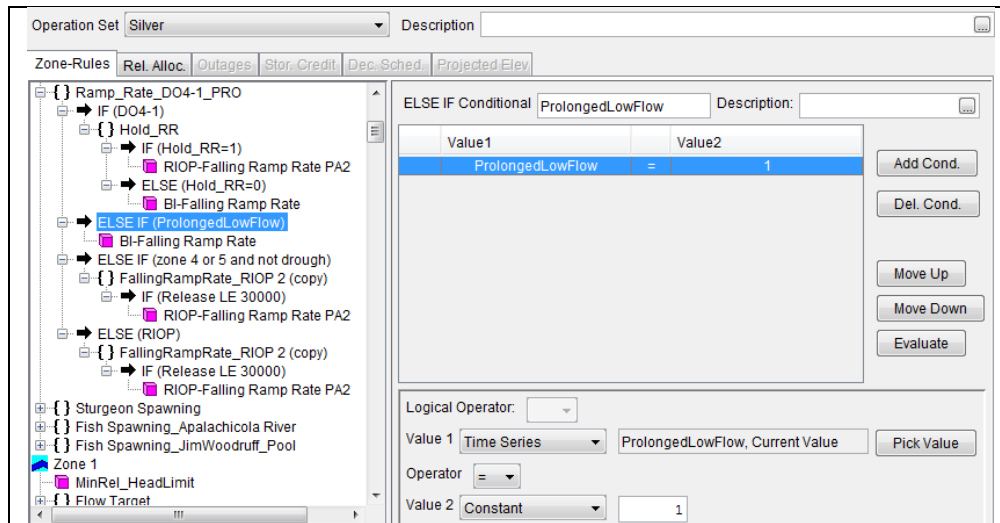


Figure E.22 Conditional Block for Ramp_Rate_DO4-1_PRO Rule

B. Crimson Operation Set

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

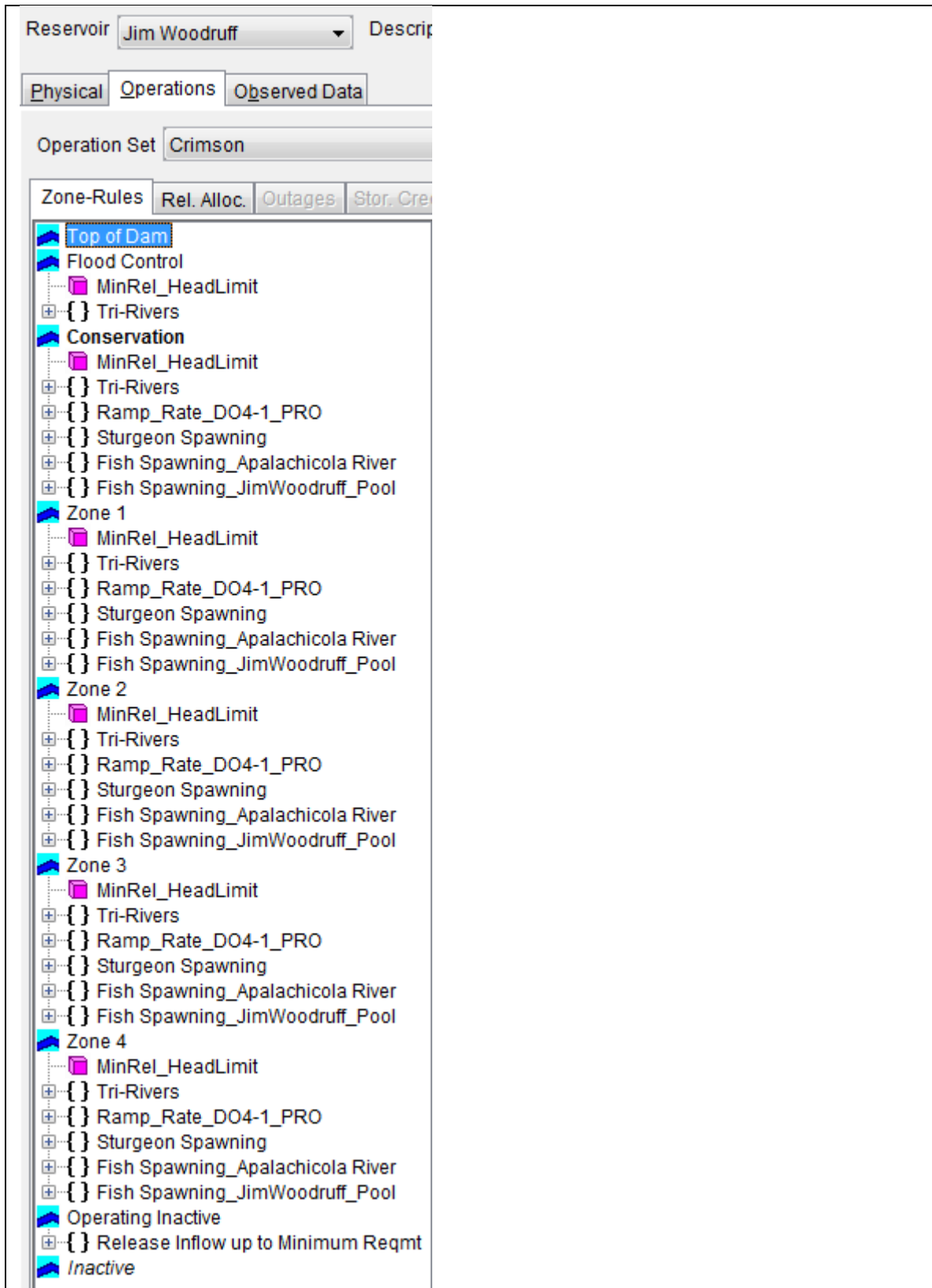


Figure E.23 Reservoir Editor- Network 2014: Operations Tab – Crimson OpSet – Zones and Rules

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

Appendix E – Jim Woodruff

		>=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.

The screenshot displays the configuration interface for a rule named "Tri-Rivers". On the left, a tree view shows the rule structure: "Tri-Rivers" (expanded), "IF (DO4-1)", "ELSE IF (Zone 4 or 5 and not DO)", and "ELSE (RIOP)".

The right side of the interface shows three configuration panels:

- IF Conditional (DO4-1):** Contains a table with columns "Value1" and "Value2". The row shows "Drought_Ops_4_1" and "1". Below the table is a "Logical Operator" dropdown set to "=", and "Value 1" is set to "Time Series" (Drought_Ops_4_1, Current Value) and "Value 2" is set to "Constant" (1).
- ELSE IF Conditional (Zone 4 or 5 and not DO):** Contains a table with columns "Value1" and "Value2". The row shows "CompositeStorage" and "4". Below the table is a "Logical Operator" dropdown set to ">=", and "Value 1" is set to "Time Series" (CompositeStorage, Current Value) and "Value 2" is set to "Constant" (4).
- ELSE Conditional (RIOP):** This panel is currently empty.

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)”

The screenshot displays a software interface for drought operations, divided into several sections:

- Decision Tree (Top Left):** A hierarchical tree structure for 'Tri-Rivers'. It starts with 'IF (DO4-1)', which branches into 'EDO' and 'ELSE IF (Zone 4 or 5 and not DO)'. The 'EDO' branch further splits into 'IF (EDO)' and 'ELSE (Not EDO)'. 'IF (EDO)' leads to 'MinRel_4550', and 'ELSE (Not EDO)' leads to 'MinRel_5050'. The 'ELSE IF (Zone 4 or 5 and not DO)' branch also leads to 'MinRel_5050'.
- Configuration Panel (Top Right):** Shows settings for 'EDO'. It includes a table with columns 'Type', 'Name', and 'Description'. The 'Name' is 'EDO' and 'Description' is empty. Below this, it shows 'Operates Release From: Jim Woodruff', 'Rule Name: MinRel_4550', and 'Function of: Date'. A graph plots 'Release (cfs)' from 4,500 to 4,600 against months (Jan to Nov), with a horizontal line at 4,550.0. There are checkboxes for 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation'.
- Configuration Panel (Bottom Right):** Shows settings for 'MinRel_5050'. It includes 'Operates Release From: Jim Woodruff', 'Rule Name: MinRel_5050', and 'Description: This flow of 5050 cfs represents the r...'. The 'Function of: Date' is set. A graph plots 'Release (cfs)' from 4,960 to 5,120 against months (Jan to Nov), with a horizontal line at 5,050.0. Similar checkboxes are present.
- Conditional Logic Panels (Bottom Left):**
 - IF Conditional:** Shows 'Value1' as 'EDO_Flow' and 'Value2' as '1'. The logical operator is '='.
 - ELSE Conditional:** Shows 'Value1' as 'EDO_Flow, Current Value' and 'Value2' as 'Constant' with a value of '1'. The logical operator is '='.

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

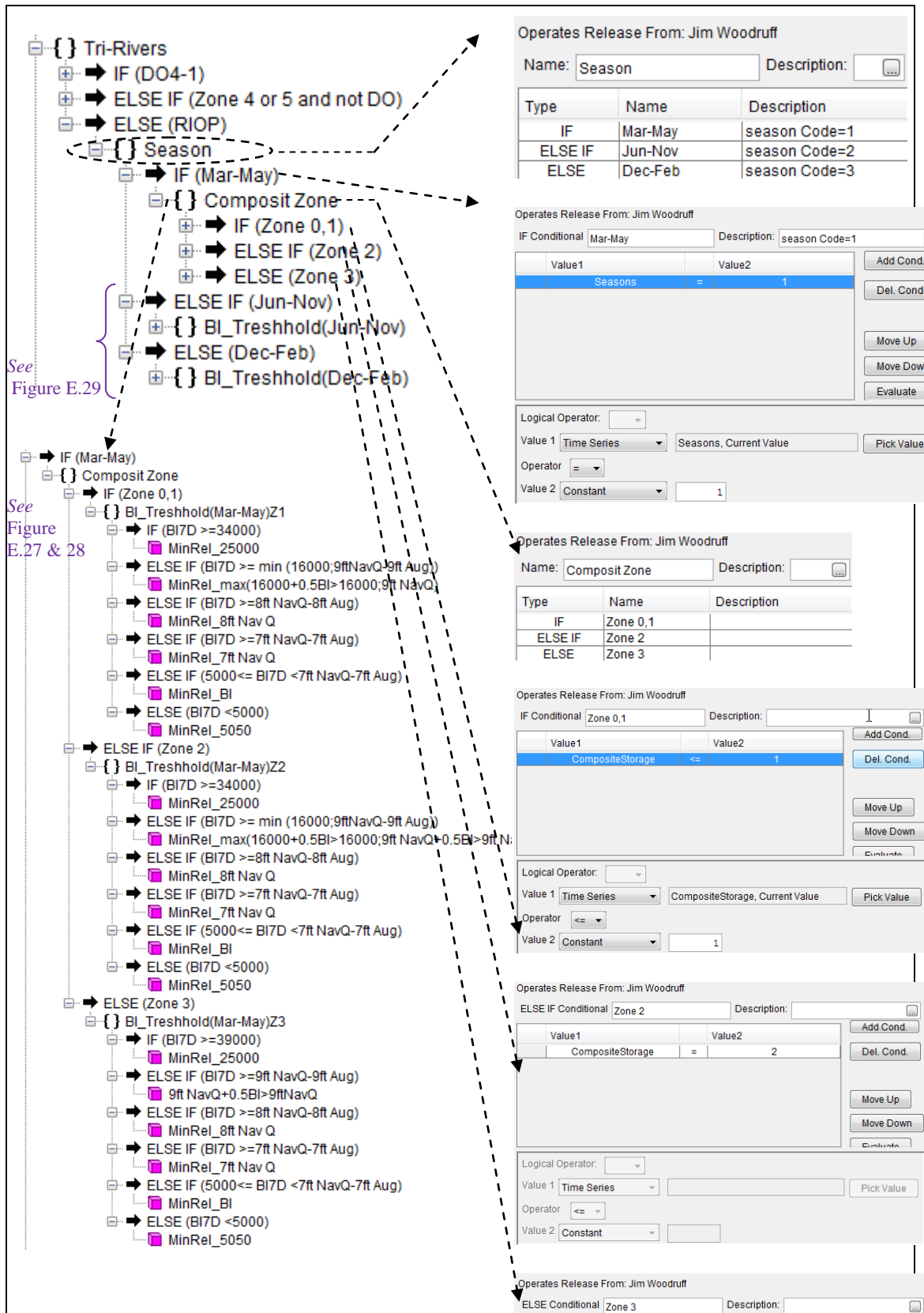


Figure E.26 Tri-Rivers (Part 3 of 6): Season– “Overview” and check for “(Mar-May)” – Part 1 of 3

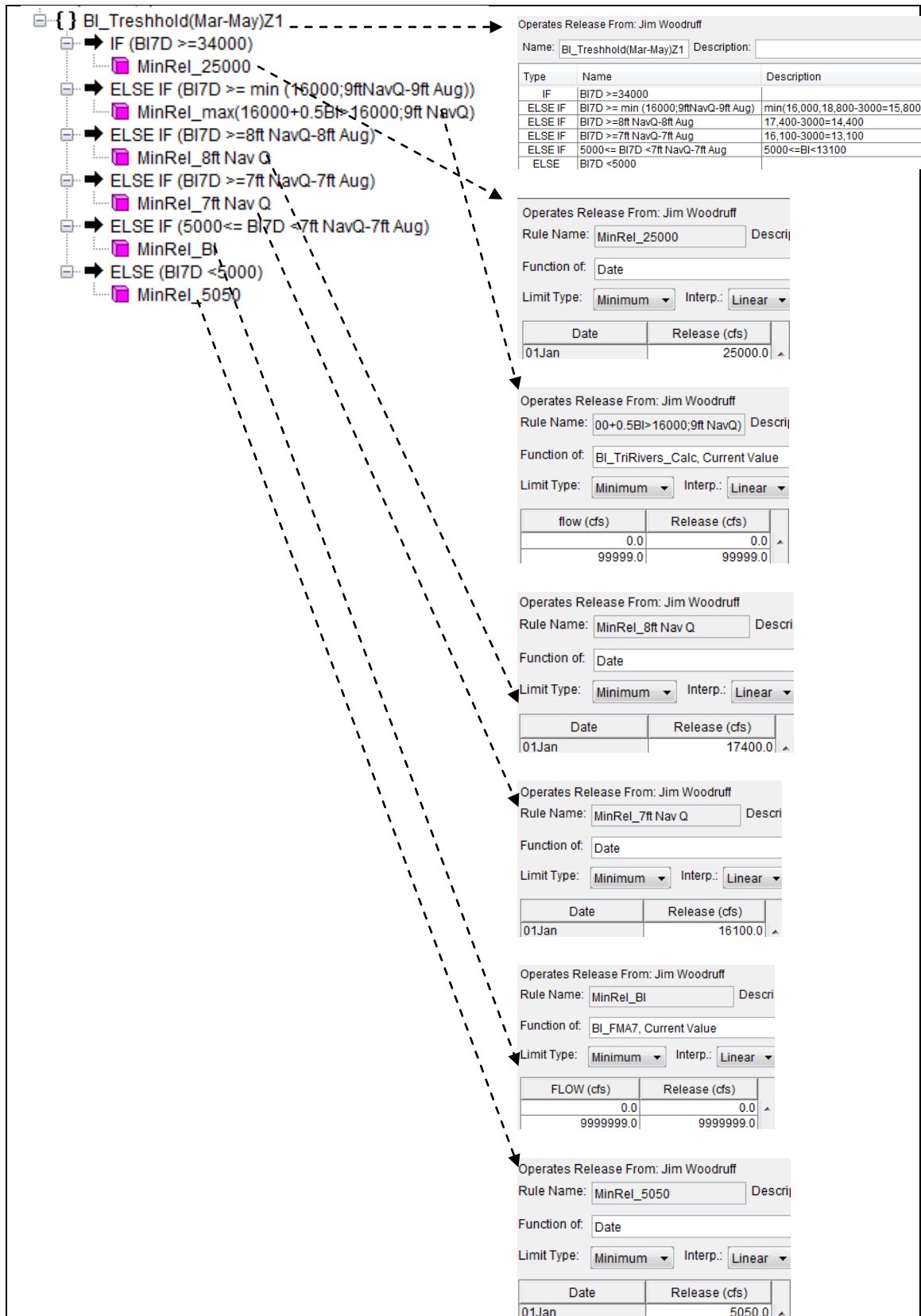


Figure E.27 Tri-Rivers (Part 4 of 6): Season– “Overview” and check for “(Mar-May)” – Part 2 of 3

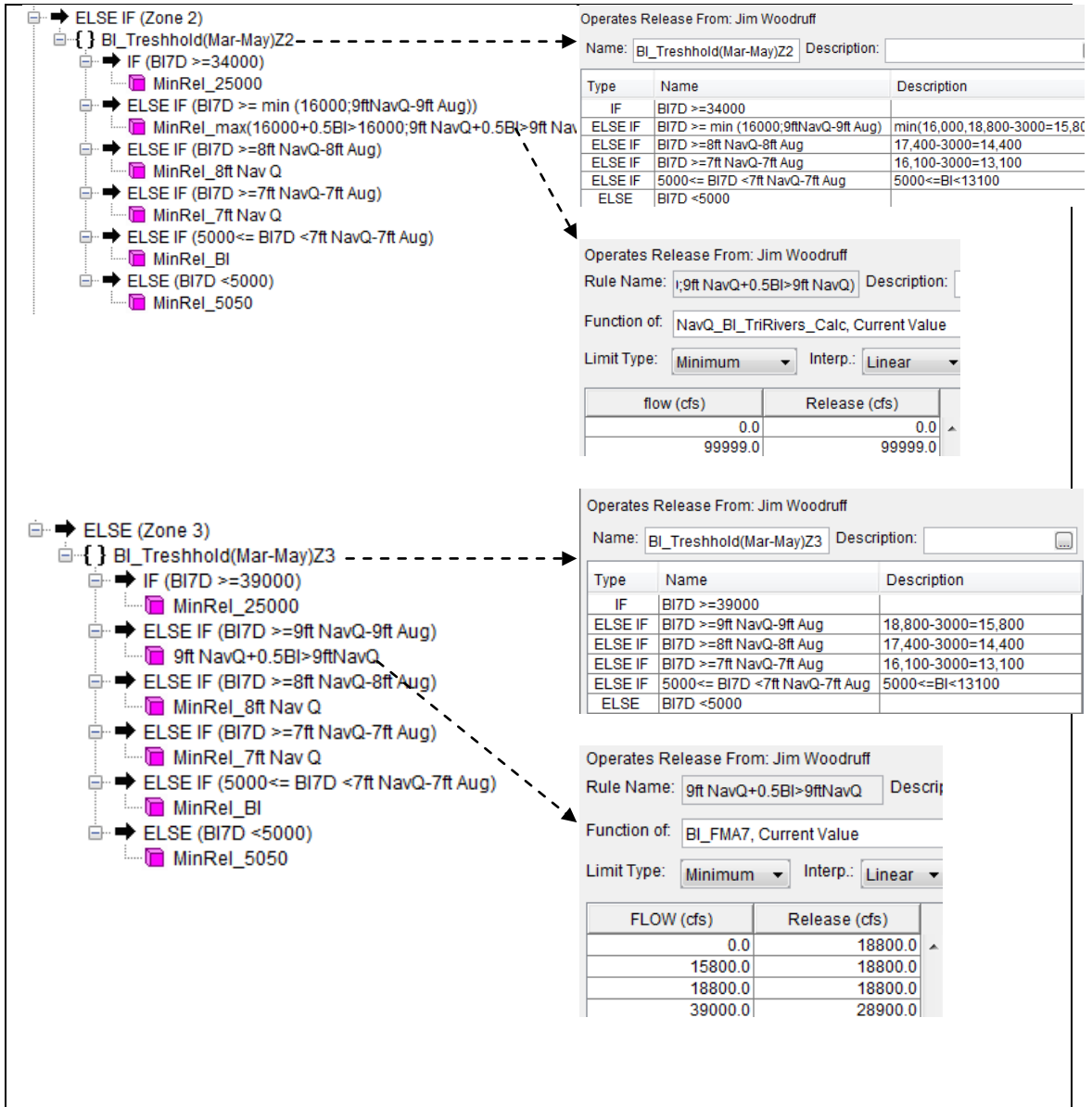


Figure E.28 Tri-Rivers (Part 5 of 6): Season--“Overview” and check for“(Mar-May)” – Part 3 of 3

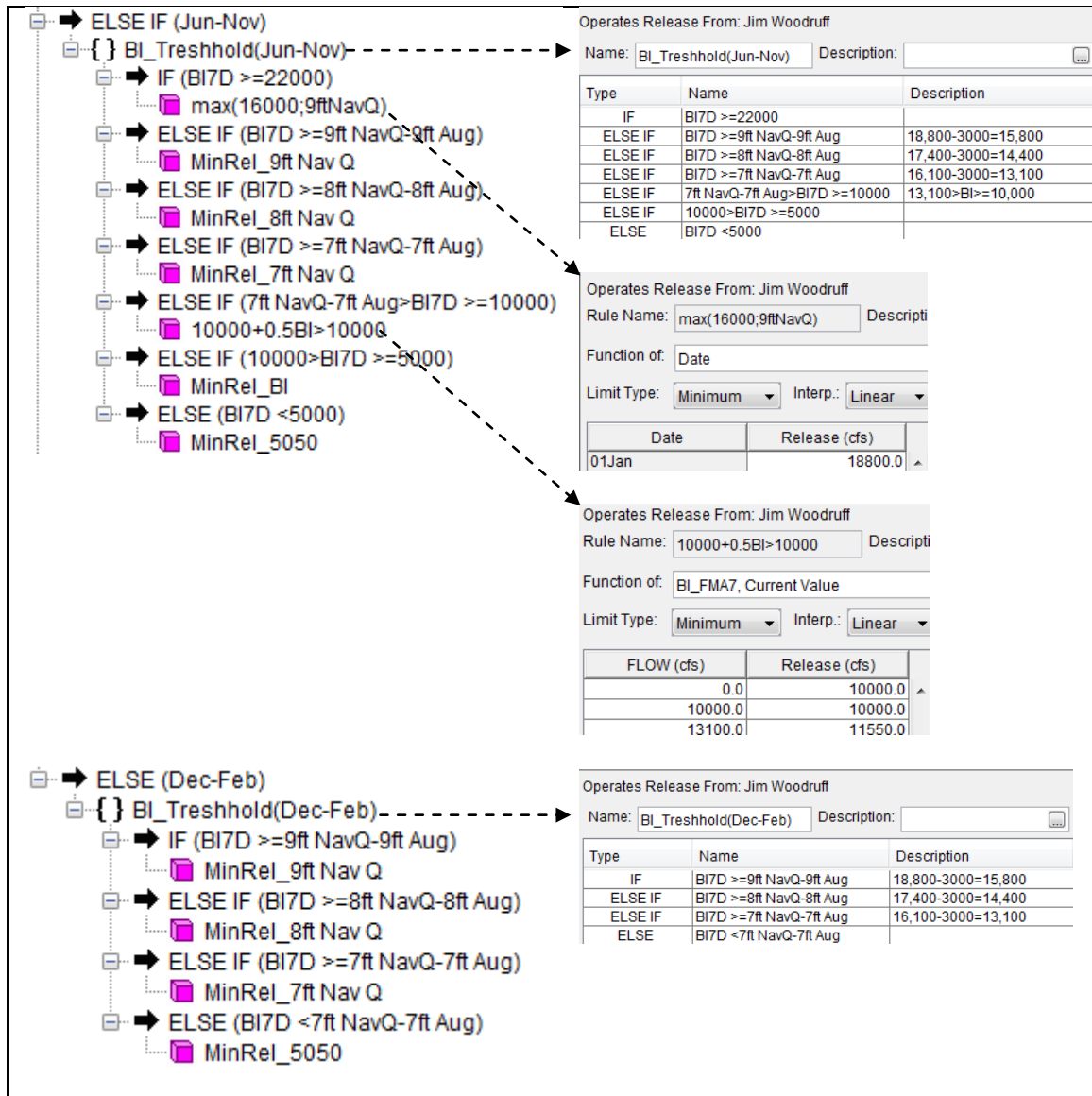


Figure E.29 Tri-Rivers (Part 6 of 6): Season– “Overview” and check for “(Jun-Nov)” and “(Dec-Feb)”

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.

Appendix E – Jim Woodruff

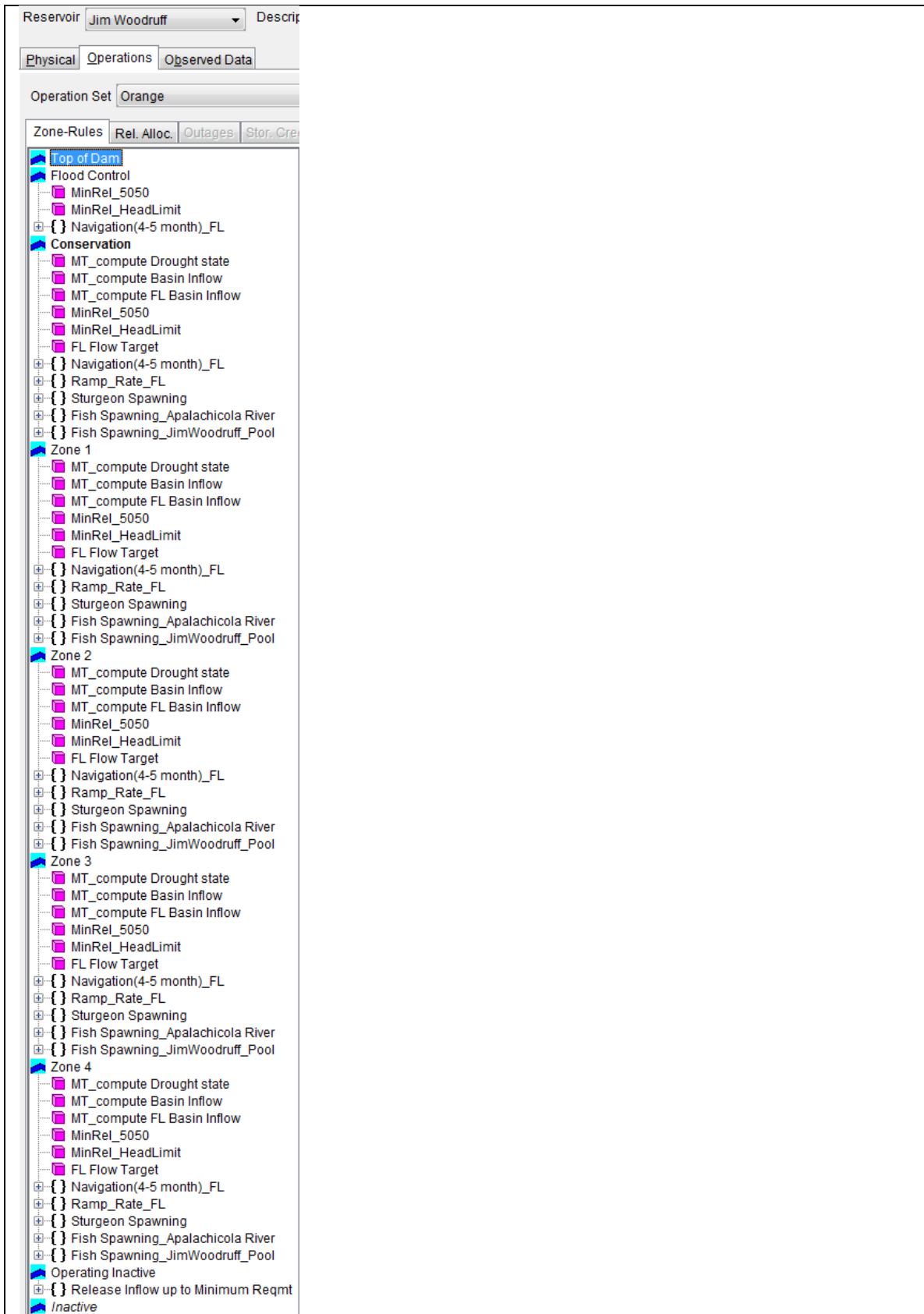


Figure E.30 Reservoir Editor- Network 2014: Operations Tab – Orange OpSet – Zones and Rules

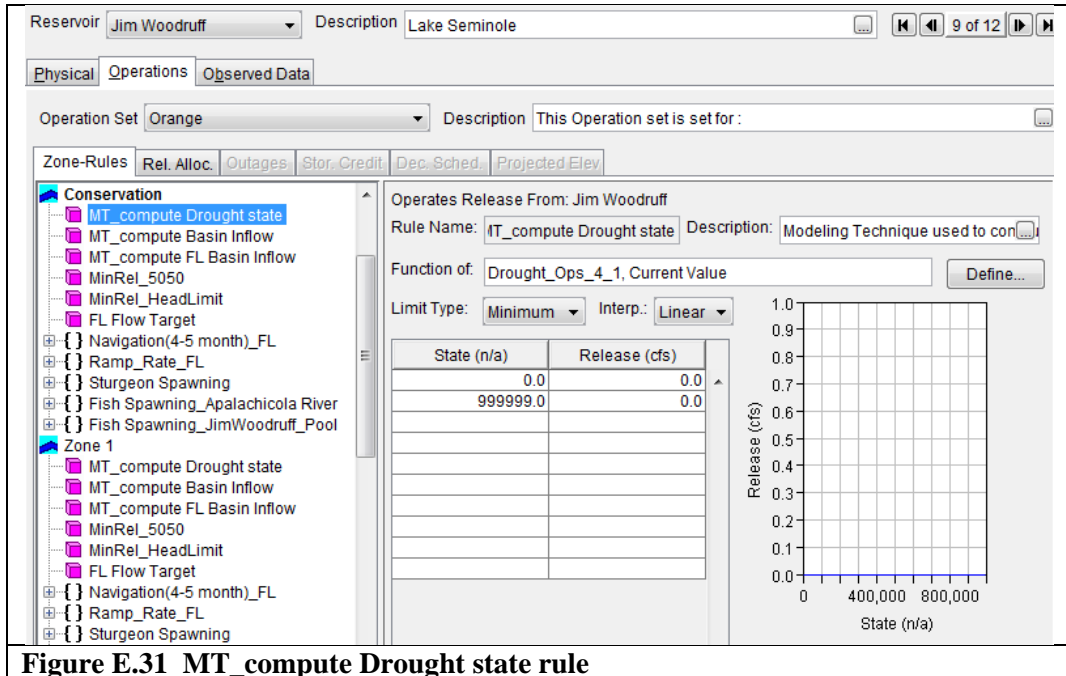


Figure E.31 MT_compute Drought state rule

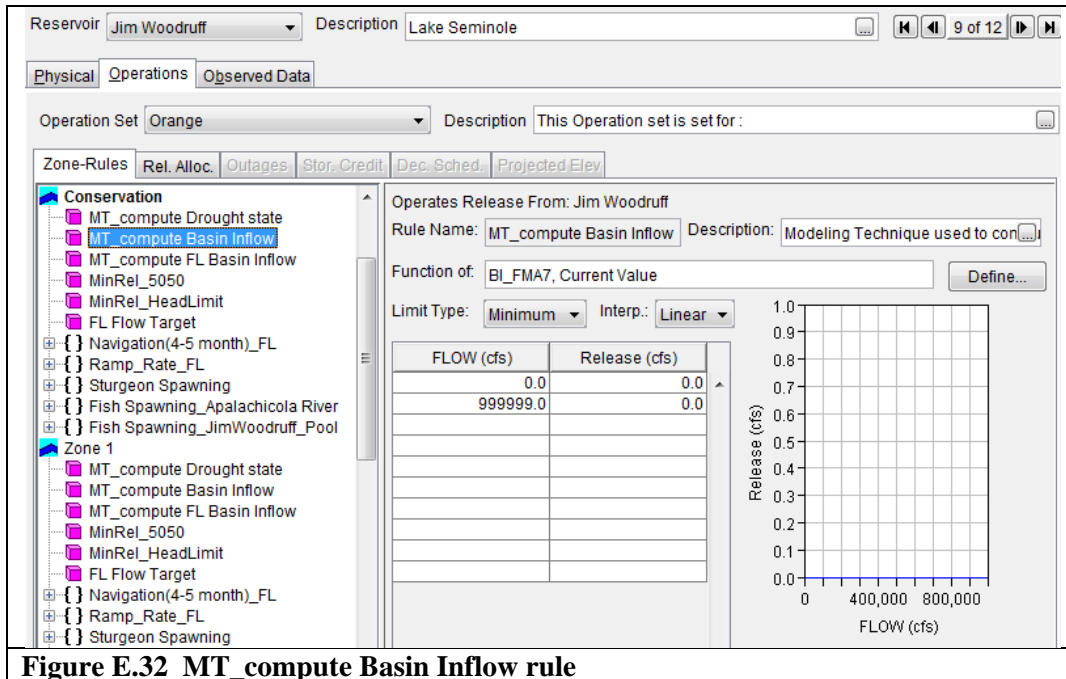


Figure E.32 MT_compute Basin Inflow rule

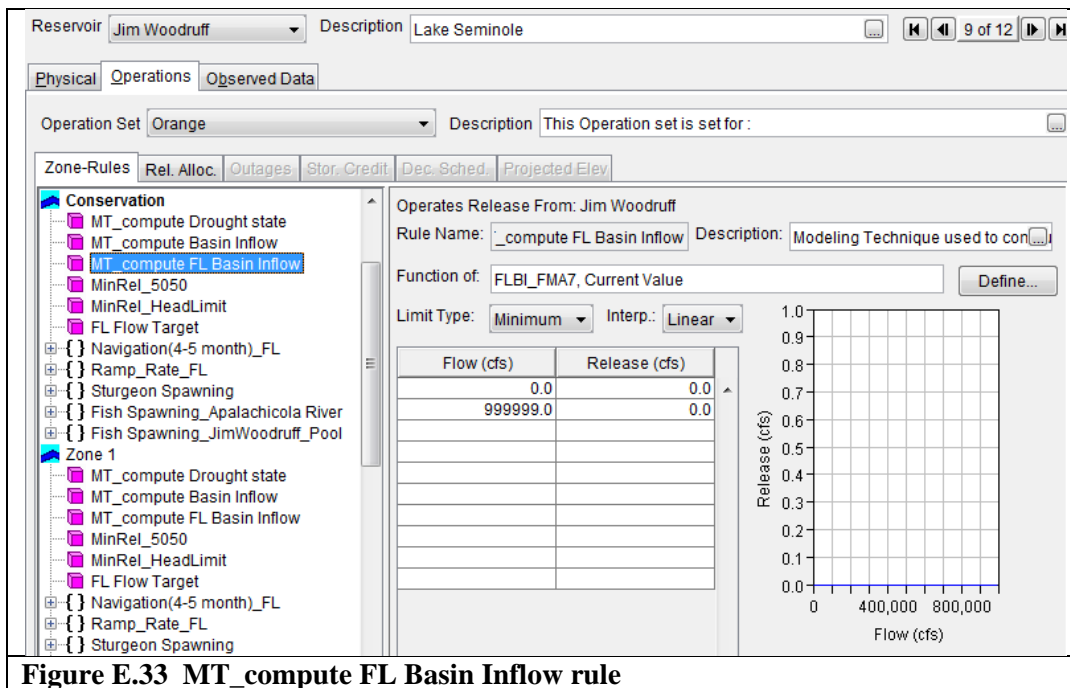
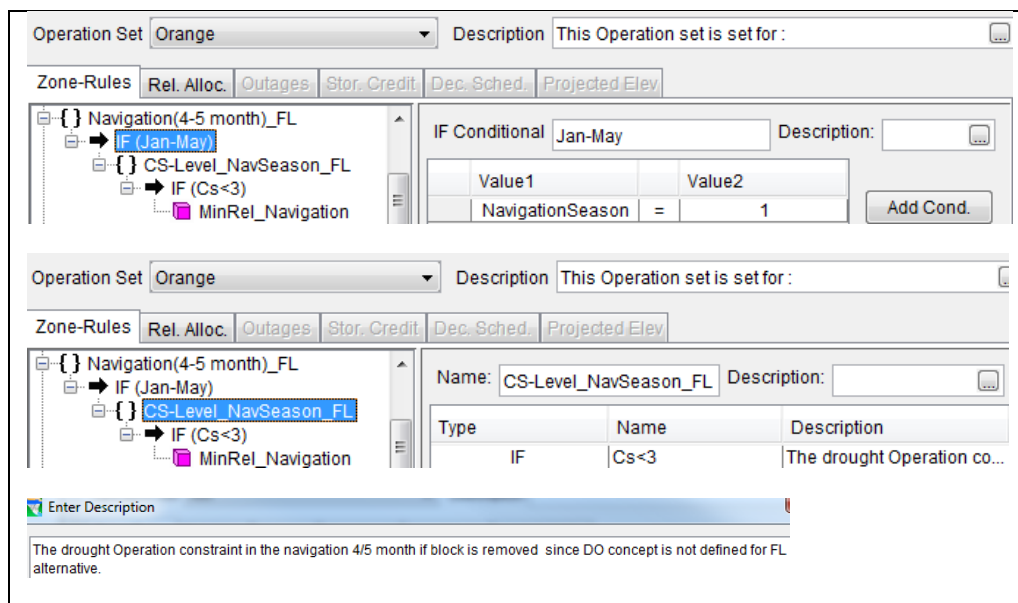


Figure E.33 MT_compute FL Basin Inflow rule

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.



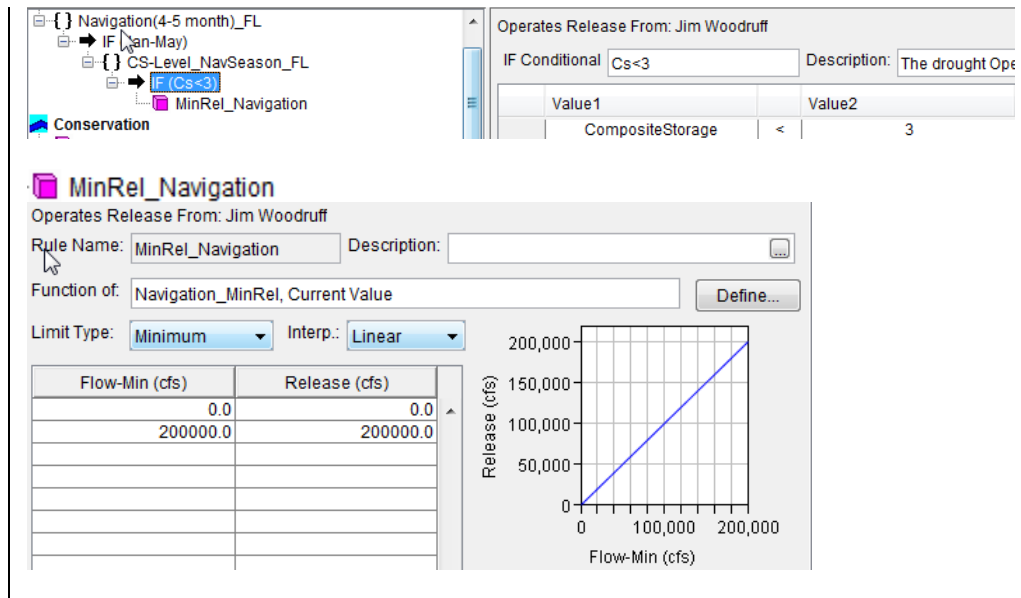


Figure E.34 Release Rules for Navigation (4-5month)_FL

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

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 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.

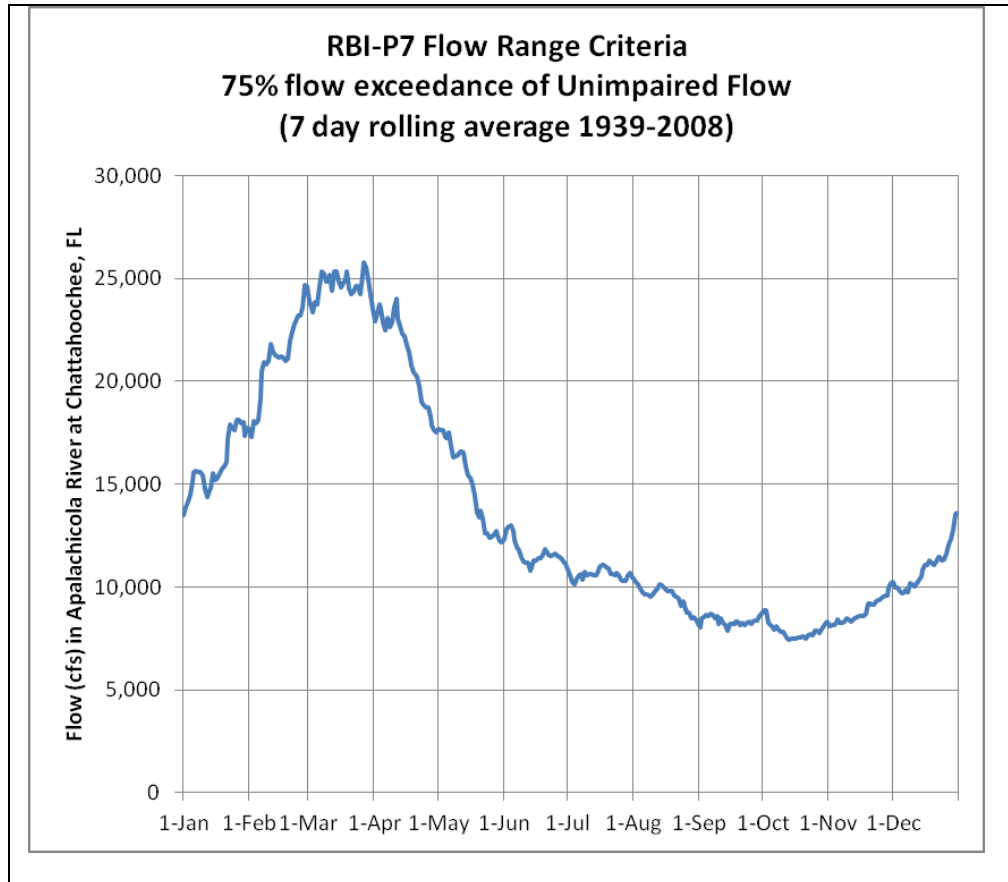


Figure E.35 Florida Flow Target-Flow range criteria

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.

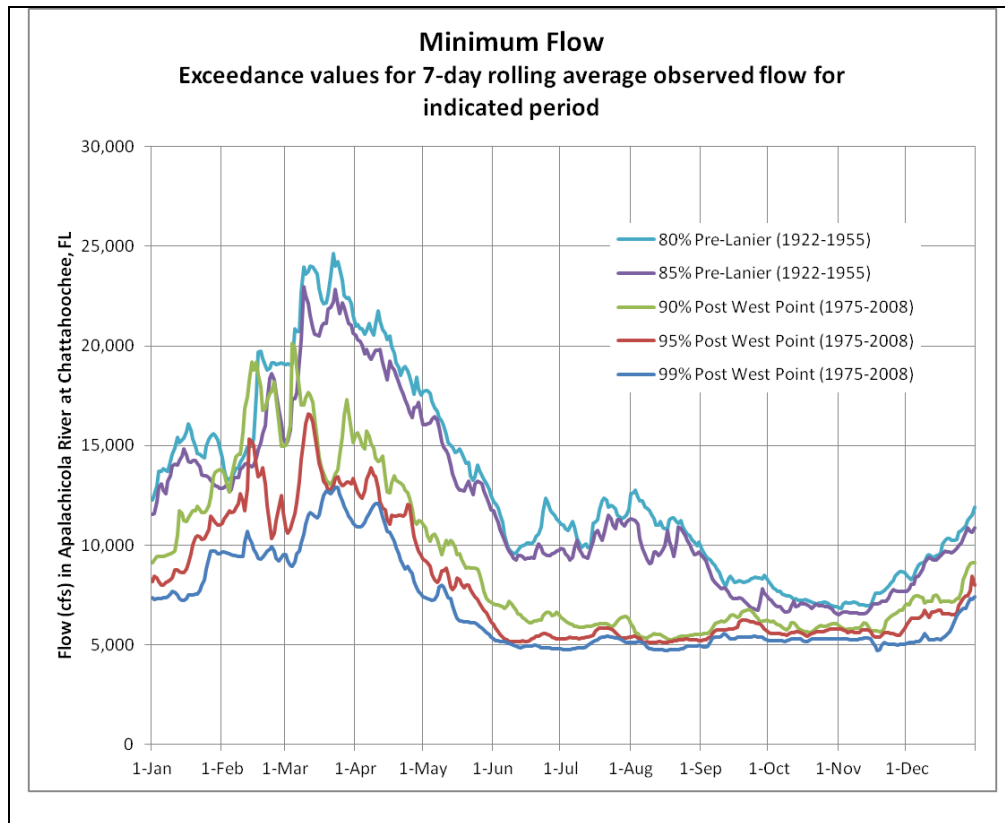


Figure E.36 Florida Flow Target-Daily Minimum Flow

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”.

Appendix E – Jim Woodruff

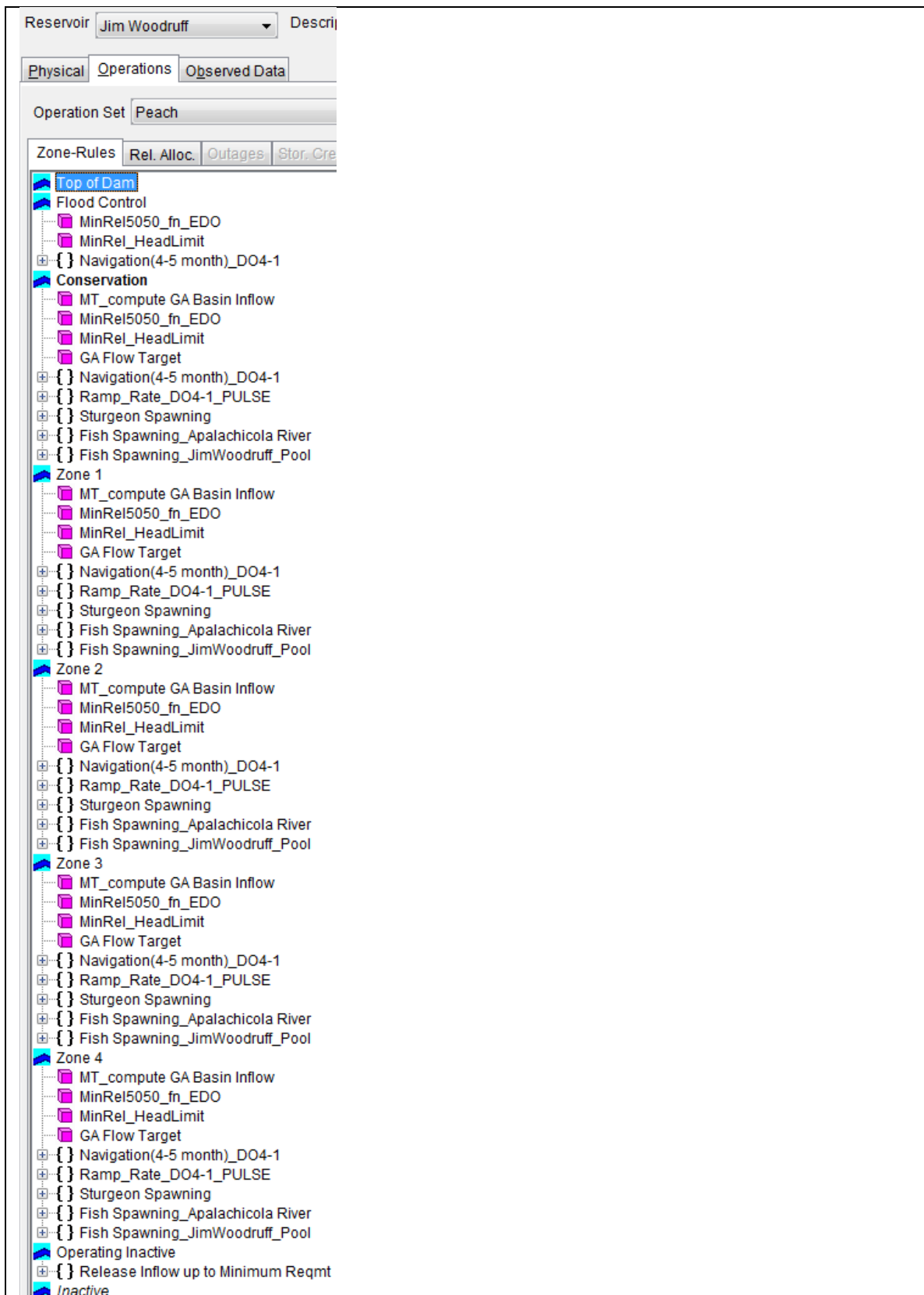


Figure E.37 Reservoir Editor- Network 2014: Operations Tab – Peach OpSet – Zones and Rules

“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.

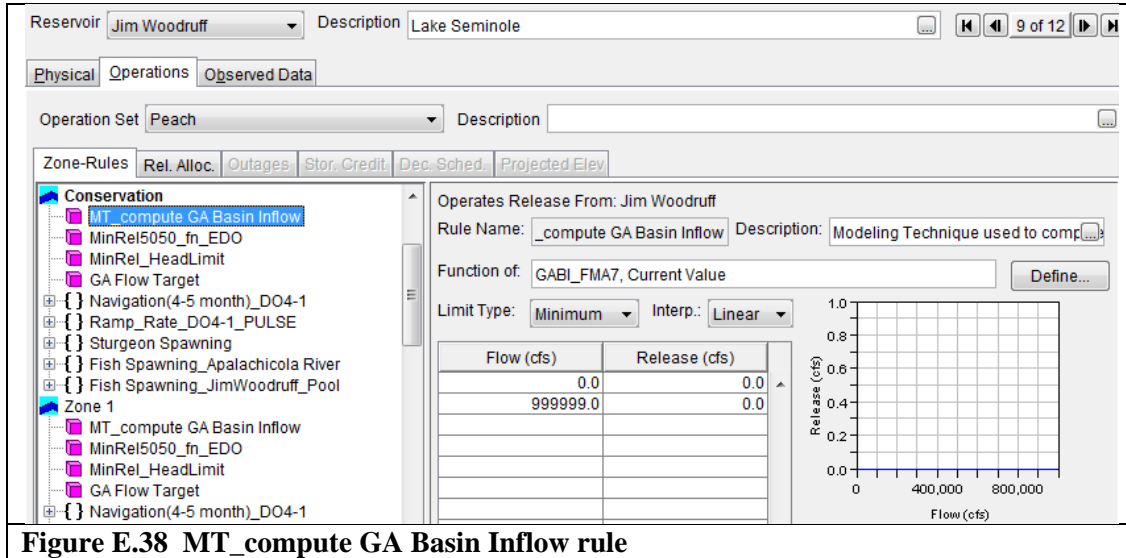


Figure E.38 MT_compute GA Basin Inflow rule

1. Navigation (4-5 month)_D04-1

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:

$$\text{Basin Inflow} = \text{Chattahoochee River flow} + \text{Lanier change in storage} + \text{West Point change in storage} + \text{WF George change in storage} + \text{Jim Woodruff change in storage}$$

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

Appendix E – Jim Woodruff

- 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	$\geq 6,500$	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 $Q = \min(10,500, \min(\text{observed moving 30-day flow}))$	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if $BI \geq 10,500$ If $BI < 10,500$ and $\geq 5,000$ If $BI < 5,000$	$\geq 10,500$ $\geq BI$ $\geq 5,000$	
In sub-period April 16-April 30		Lanier > 1066' , and West Point > 632' , and Walter F George > 187'	Maintain $Q = \min(22,500, \max(10,500, \min(\text{observed March 17-April 15 daily flow})))$	Entire or partial BI above SLF, subject to available Storage capacity
June-Nov	Zone 1,2, and 3	$BI \geq 10476$ & previous seven day's Chattahoochee gage flow < 5100	\geq 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
		$BI \geq 7181$ and < 10476 & previous seven day's Chattahoochee gage flow < 5100	\geq 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	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	$\geq 4,500$	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.

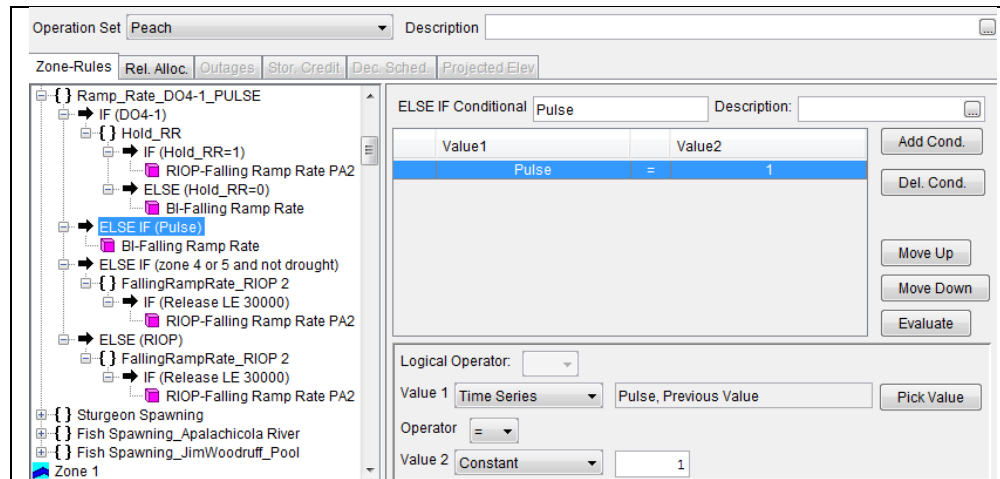


Figure E.39 Conditional Block for *Ramp_Rate_DO4-1_PULSE* Rule

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”.

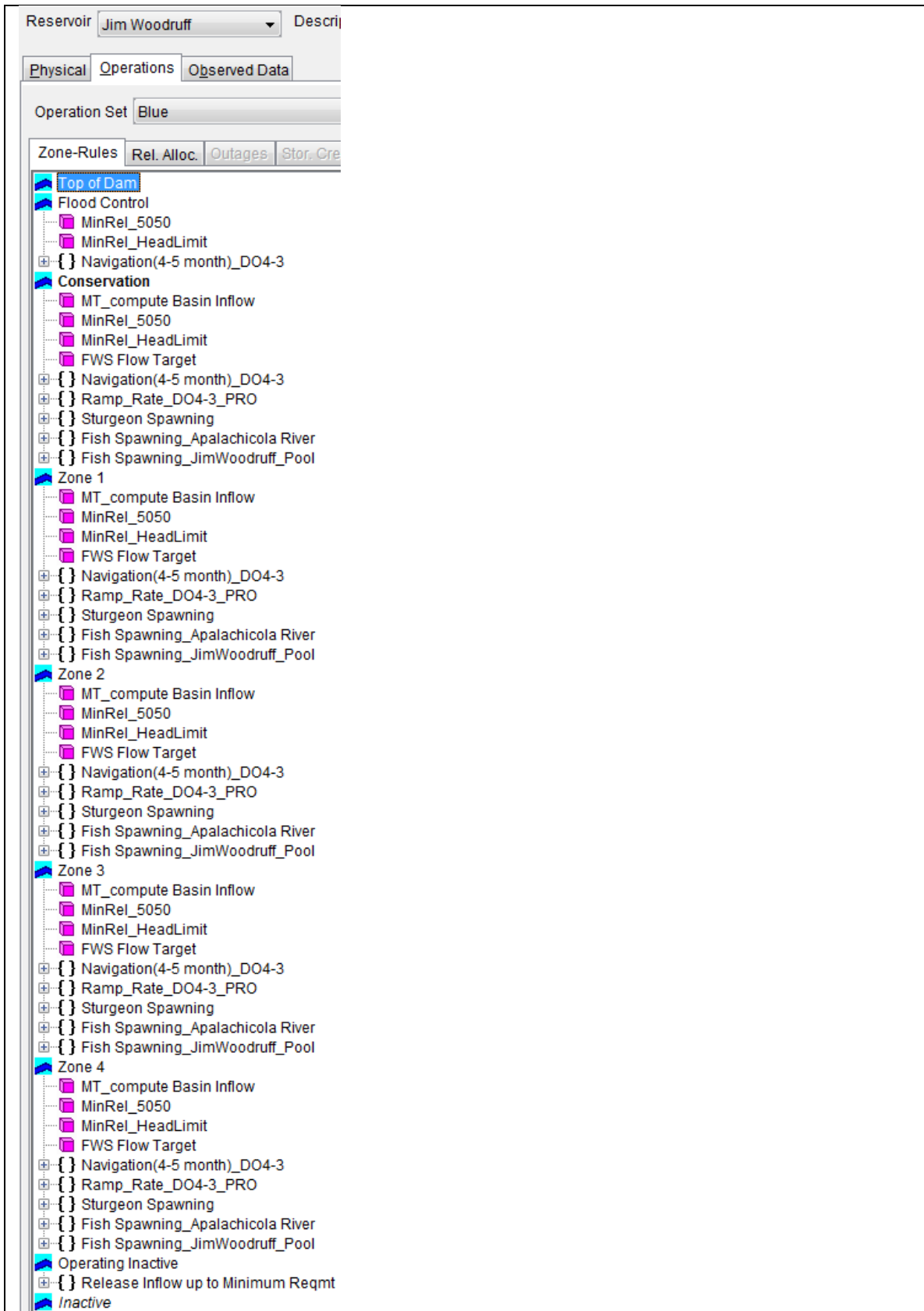


Figure E.40 Reservoir Editor- Network 2014: Operations Tab – Blue OpSet – Zones and Rules

Appendix E – Jim Woodruff

“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.

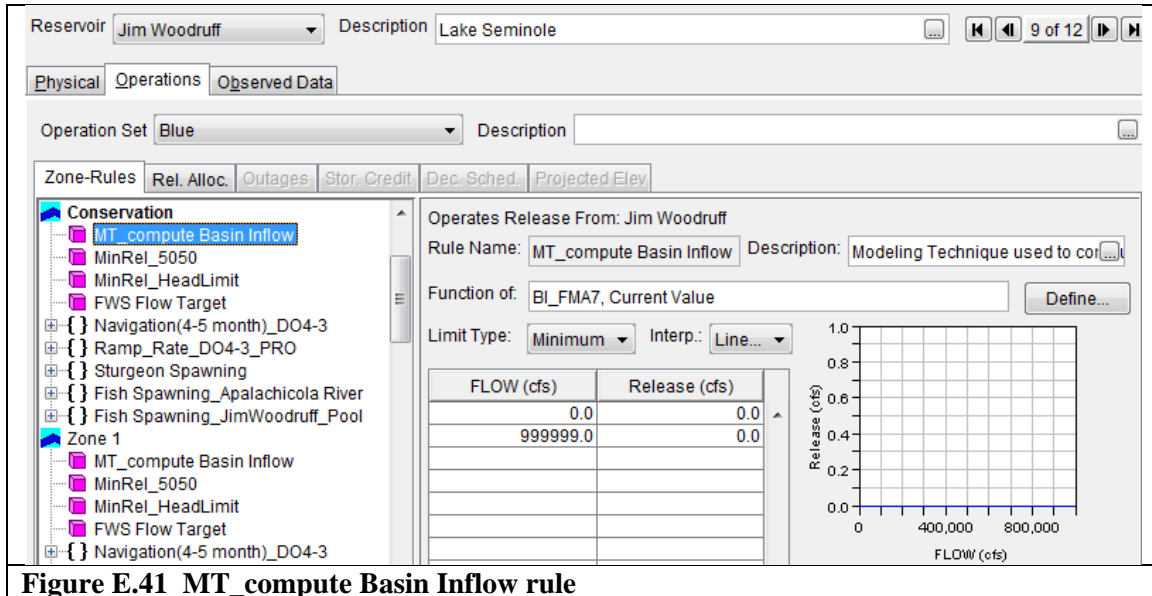


Figure E.41 MT_compute Basin Inflow rule

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.

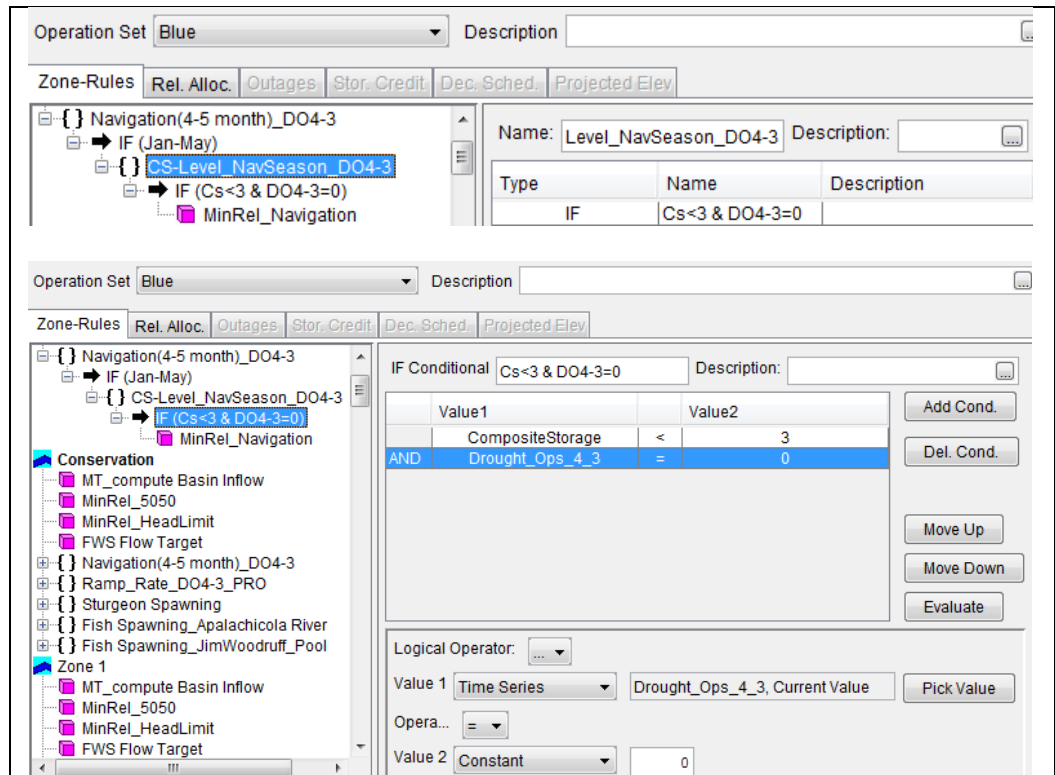


Figure E.42 Release Rules for *Navigation (4-5month)_DO4-3*

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.

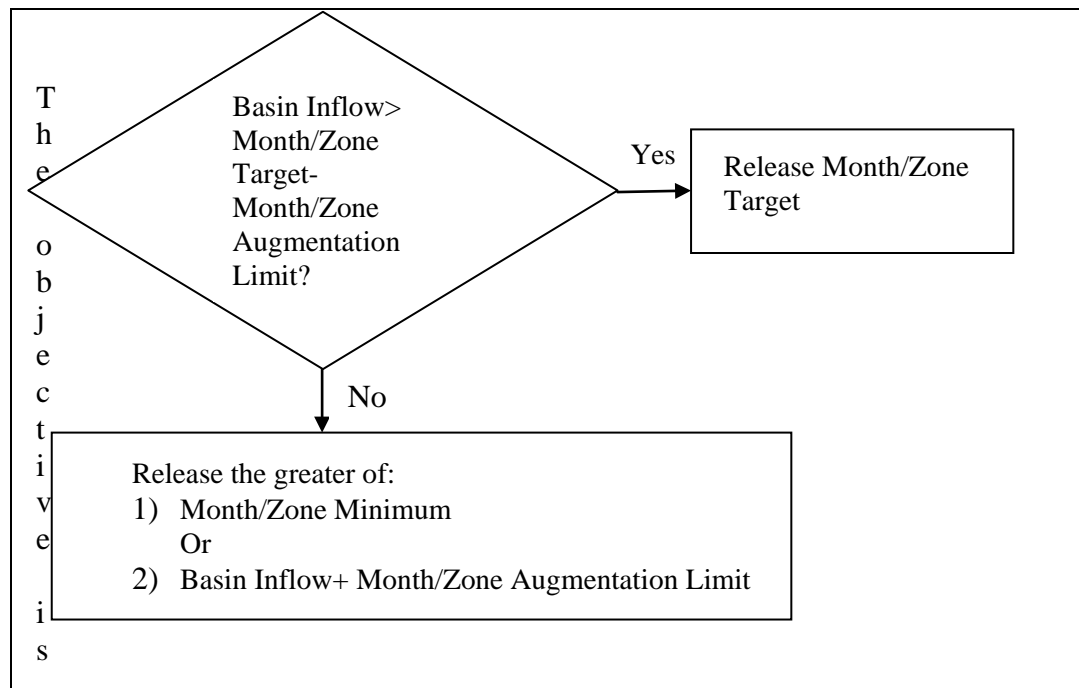


Figure E.43 FWS Flow Target

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.

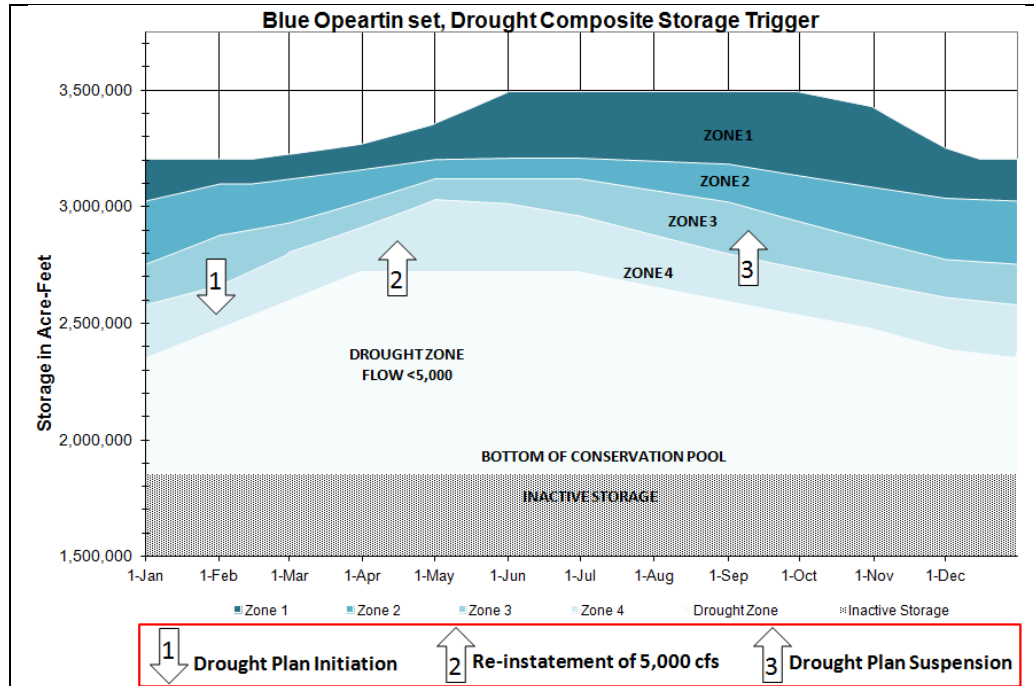


Figure E.44 Blue Operation Set-Drought Composite Storage Triggers

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”.

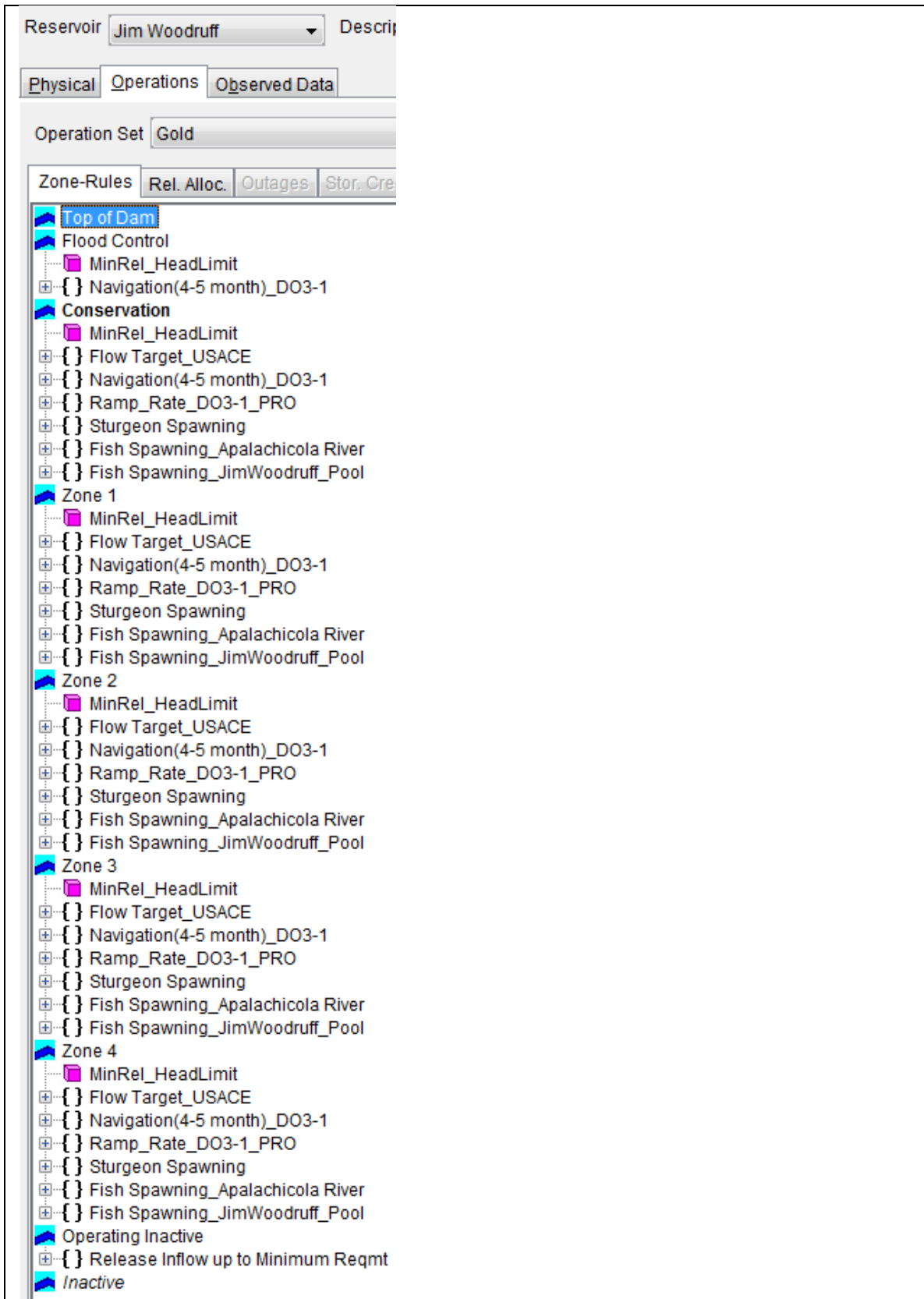


Figure E.45 Reservoir Editor- Network 2014: Operations Tab – Gold OpSet – Zones and Rules

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.

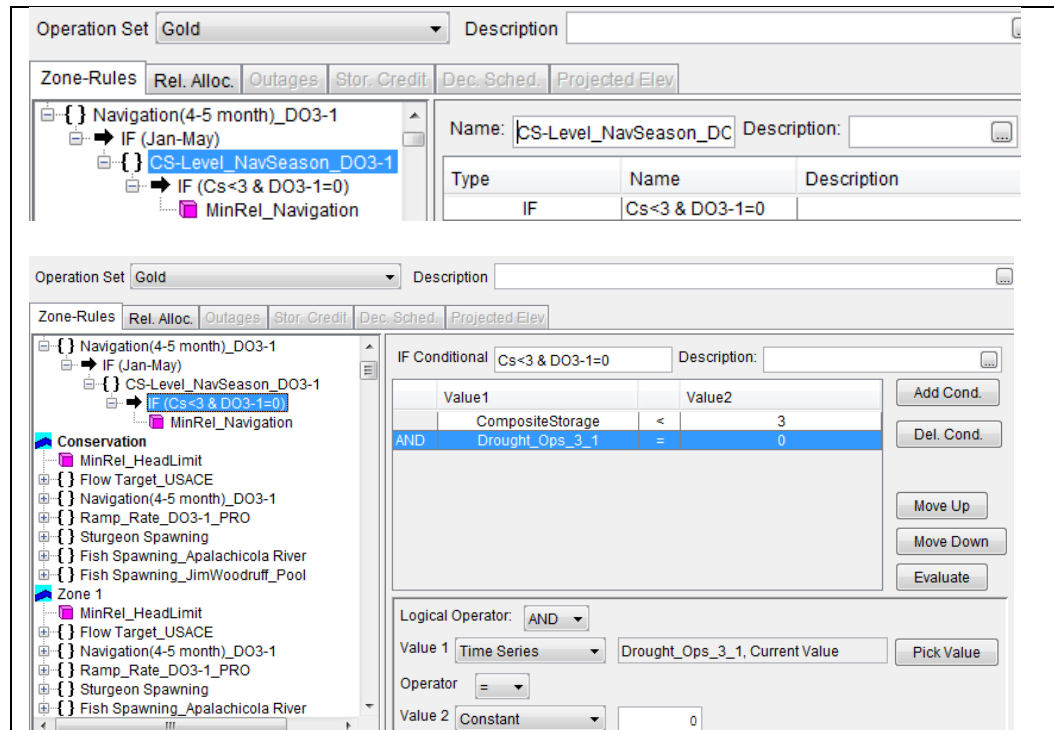


Figure E.46 Release Rules for Navigation (4-5month)_DO3-1Rule

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 E.47. Note that composite storages are defined based on Revised Action Zones.

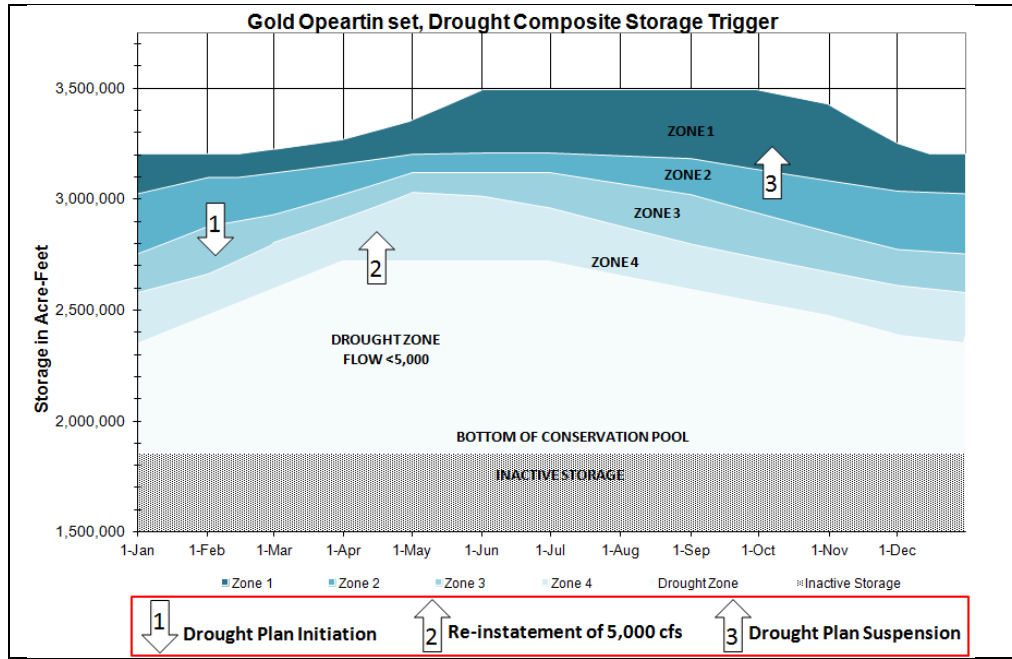


Figure E.47 Gold Operation Set-Drought Composite Storage Triggers

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Appendix F – Flow-Thru Reservoirs

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Appendix F – Flow-Thru Reservoirs

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.

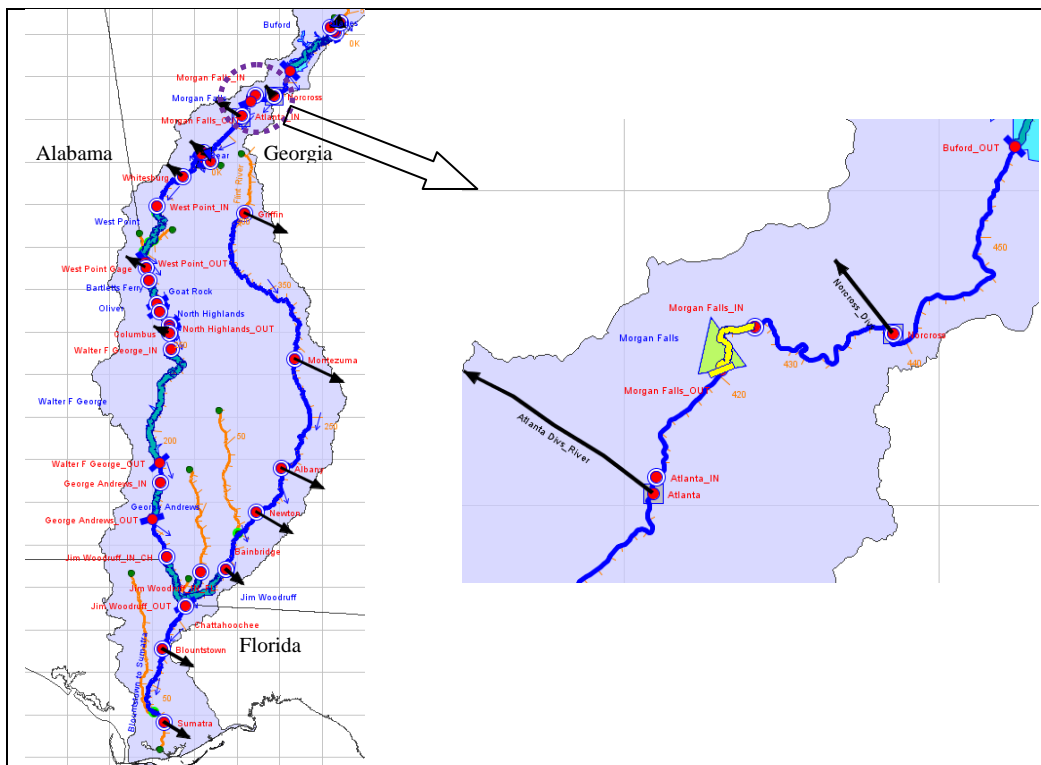


Figure F.01 HEC-ResSim Map Display Showing Location of Morgan Falls

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

Appendix F – Flow-Thru Reservoirs – Morgan Falls



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.

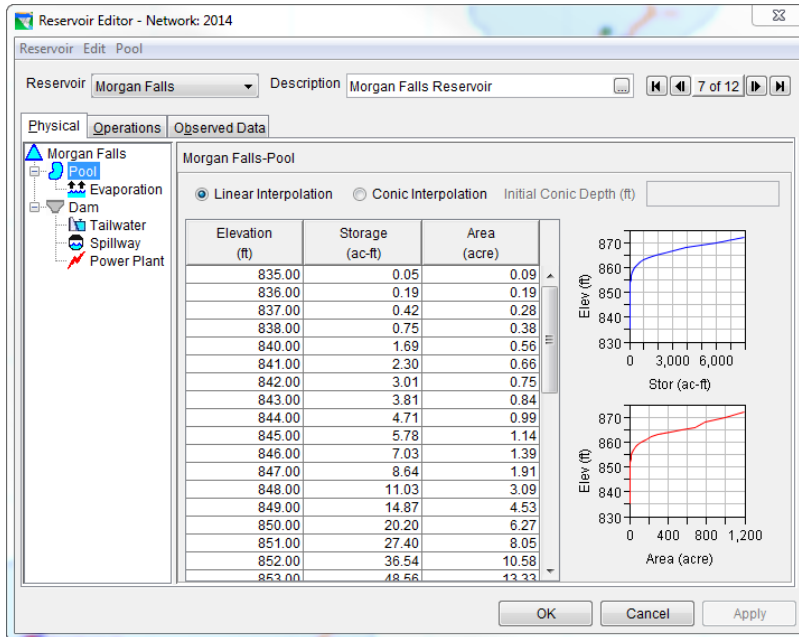


Figure F.03 Morgan Falls Reservoir Editor – Network 2014: Physical Tab – Pool

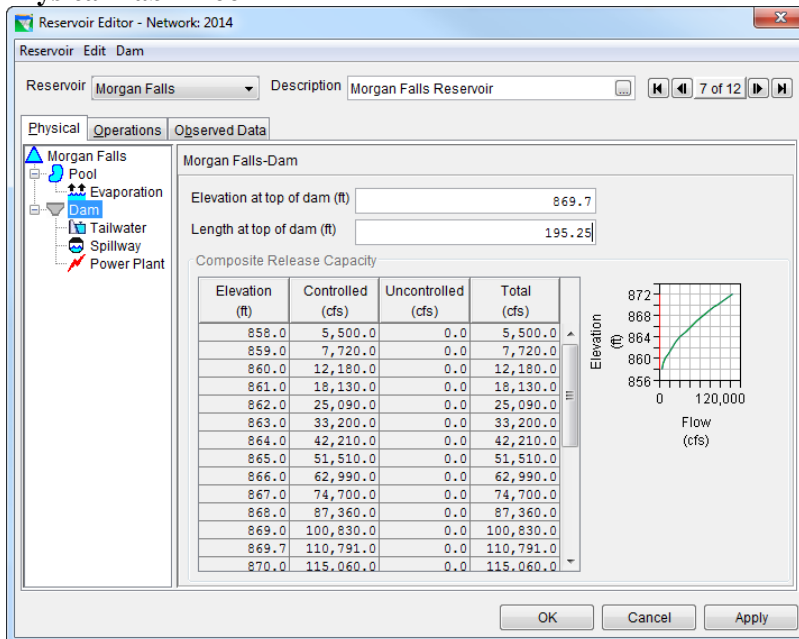


Figure F.04 Morgan Falls Reservoir Editor – Network 2014: Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
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)

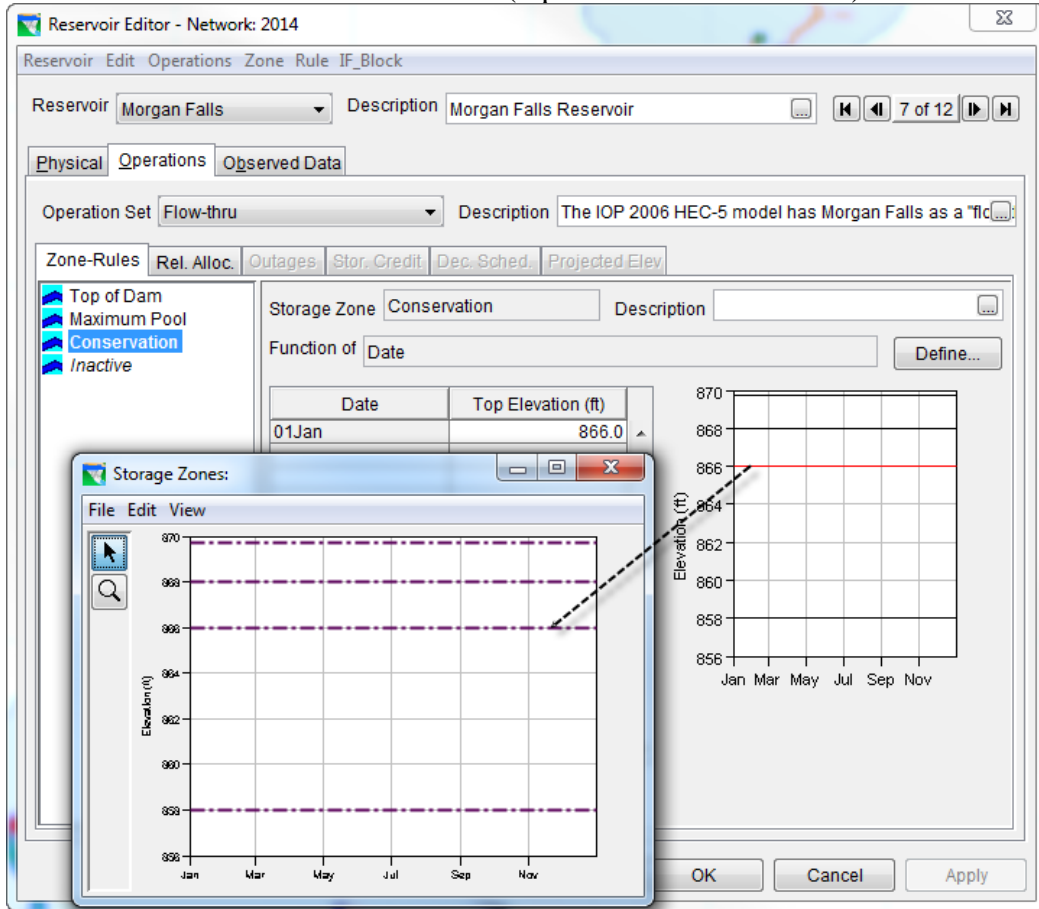


Figure F.05 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – Flow-thru Guide Curve

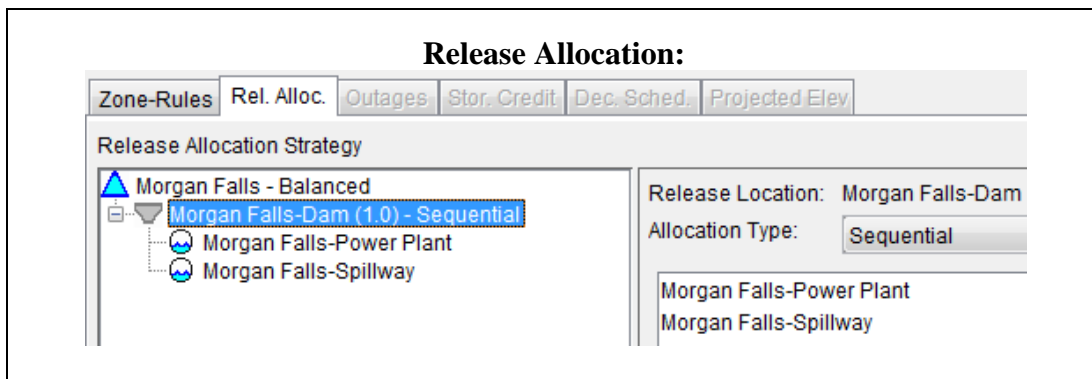


Figure F.06 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – Flow-thru Release Allocation

Appendix F – Flow-Thru Reservoirs – Morgan Falls

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.

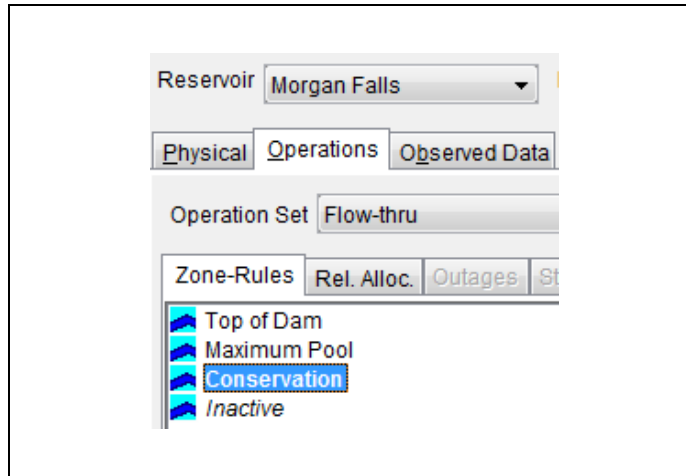


Figure F.07 Morgan Falls Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* – Zones

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.

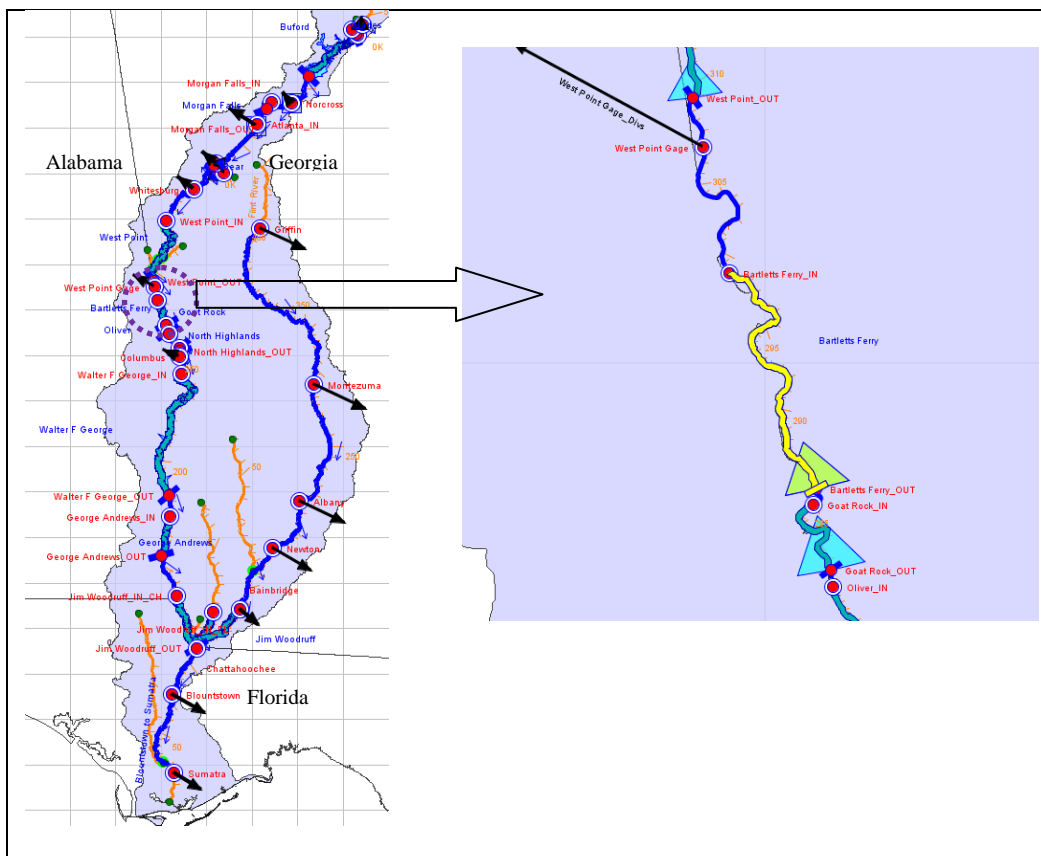


Figure F.08 HEC-ResSim Map Display Showing Location of Bartletts Ferry

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

Appendix F – Flow-Thru Reservoirs – Bartletts Ferry



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.

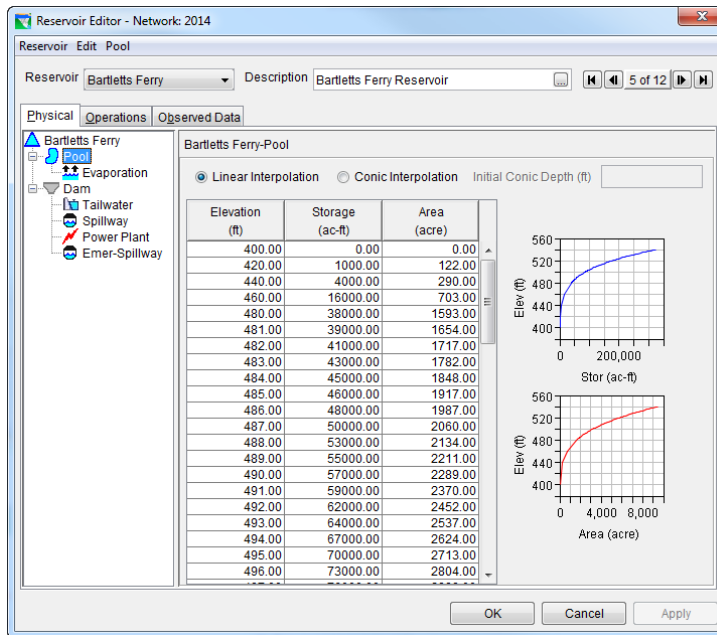


Figure F.10 Bartletts Ferry Reservoir Editor – Network 2014: Physical Tab – Pool

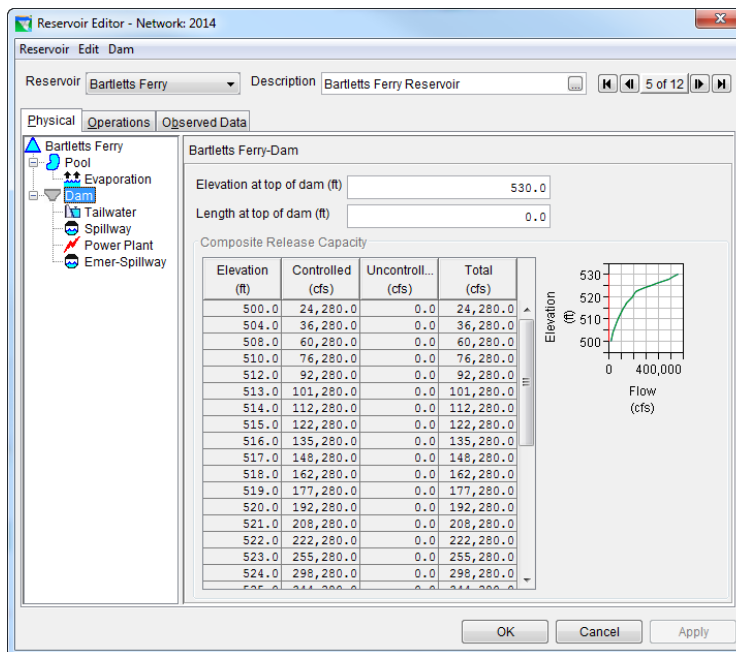


Figure F.11 Bartletts Ferry Reservoir Editor – Network 2014: Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
Zones	Season = 1Jan - 31Dec
Top of Dam	530
Conservation	521
<i>Inactive</i>	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)

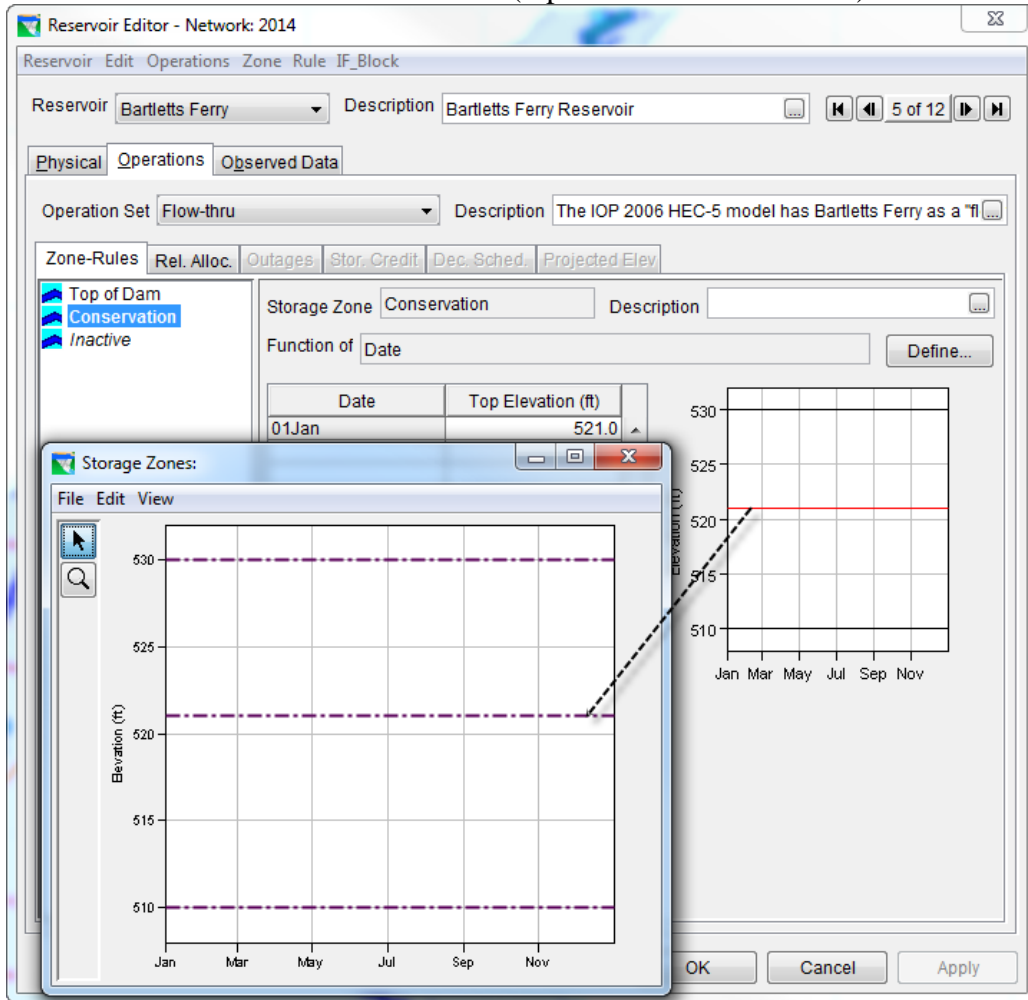


Figure F.12 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – Flow-thru Guide Curve

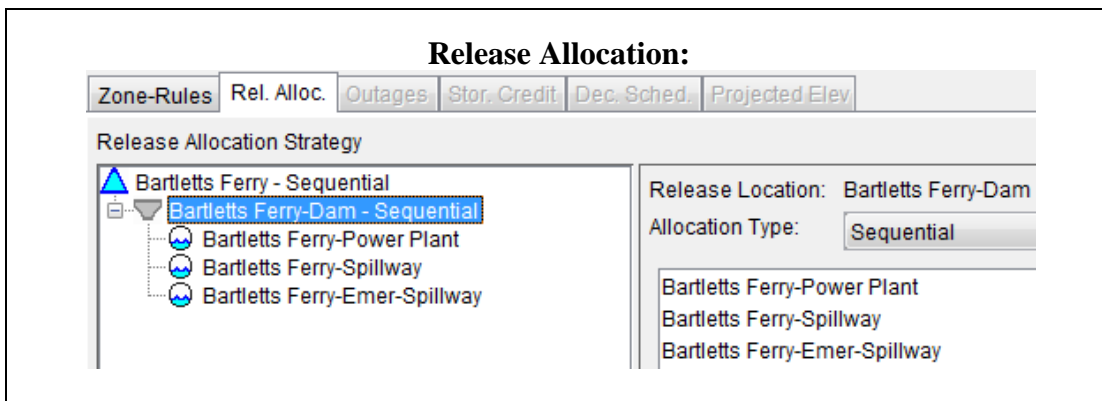


Figure F.13 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – Flow-thru Release Allocation

Appendix F – Flow-Thru Reservoirs – Bartletts Ferry

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.

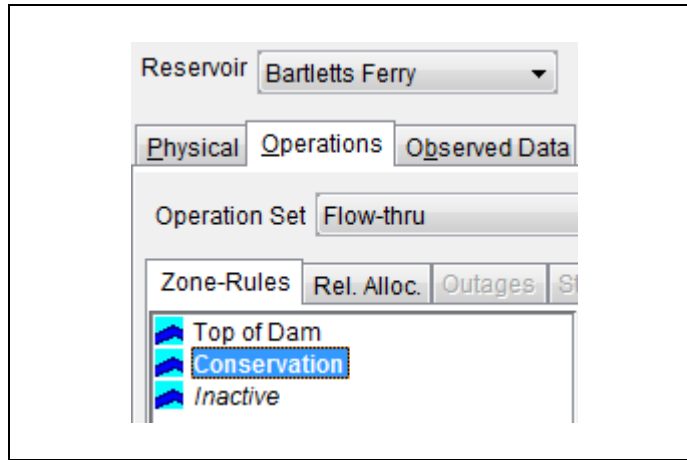


Figure F.14 Bartletts Ferry Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* – Zones

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.

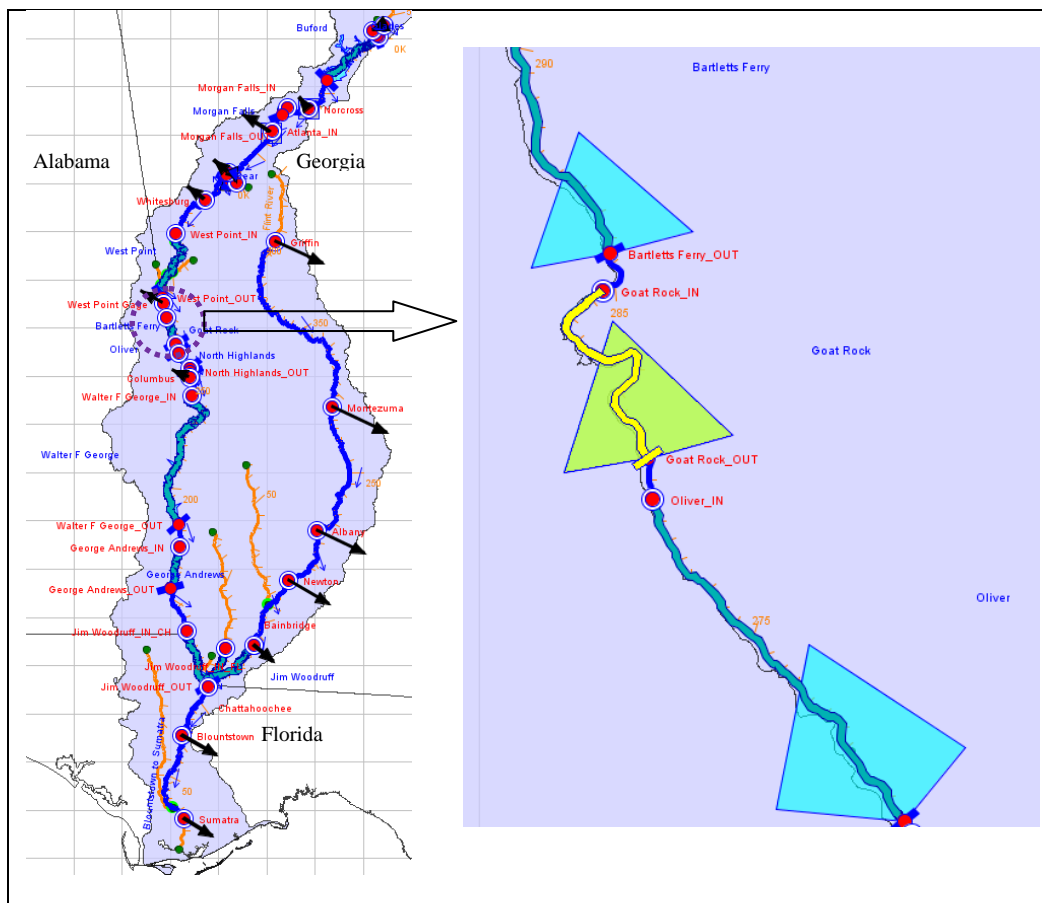


Figure F.15 HEC-ResSim Map Display Showing Location of Goat Rock

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

Appendix F – Flow-Thru Reservoirs – Goat Rock



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.

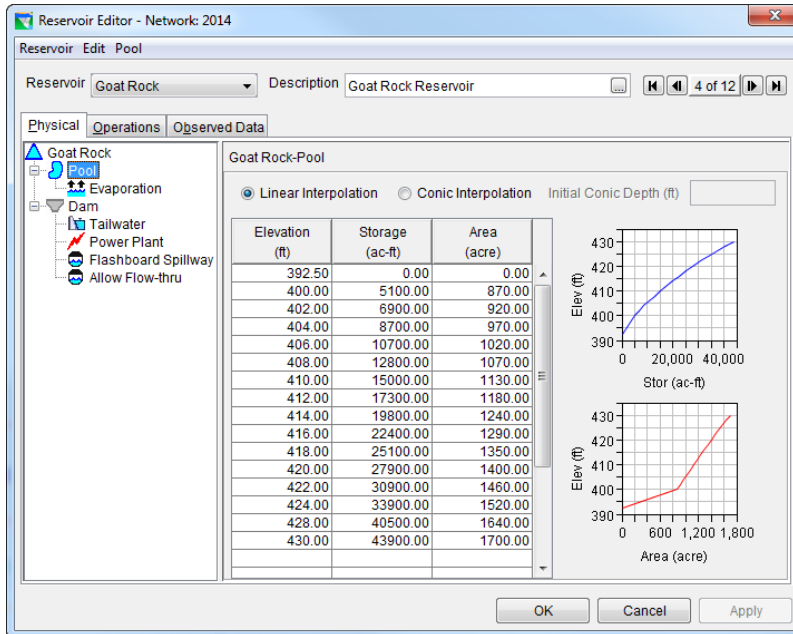


Figure F.17 Goat Rock Reservoir Editor – Network 2014: Physical Tab – Pool

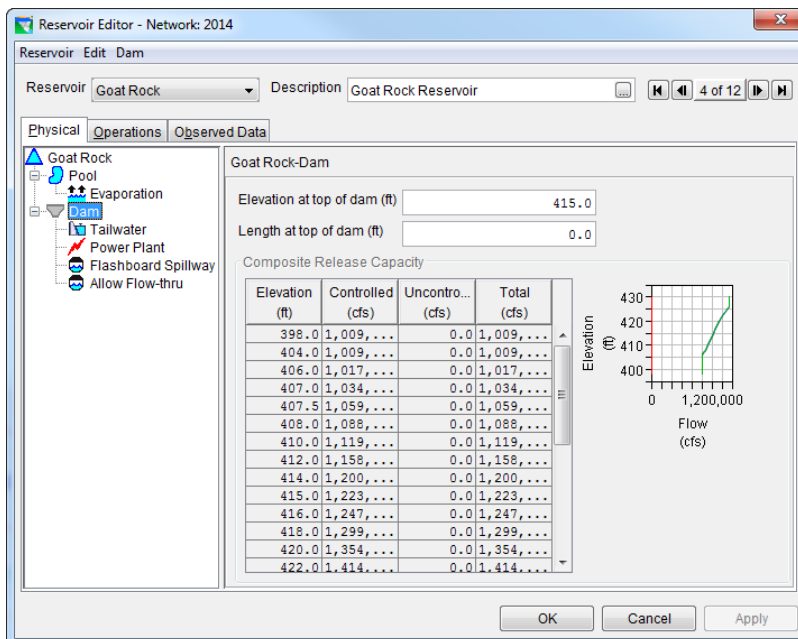


Figure F.18 Goat Rock Reservoir Editor – Network 2014: Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
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)

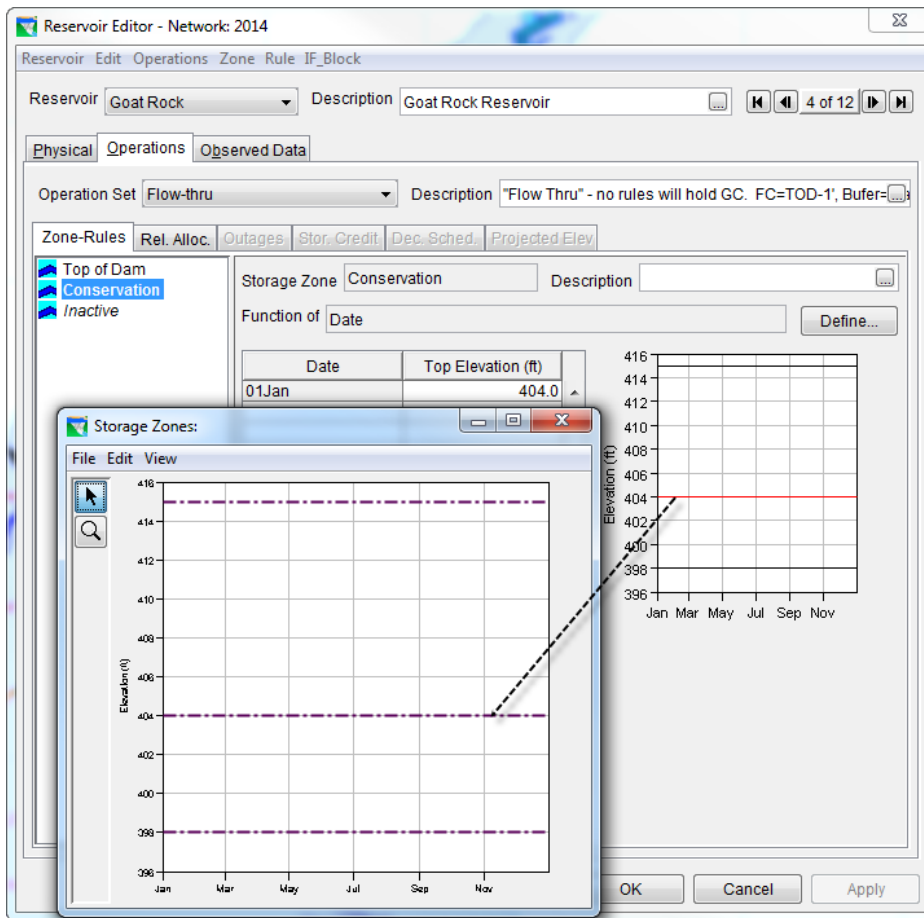


Figure F.19 Goat Rock Reservoir Editor – Network 2014: Operations Tab – Flow-thru Guide Curve

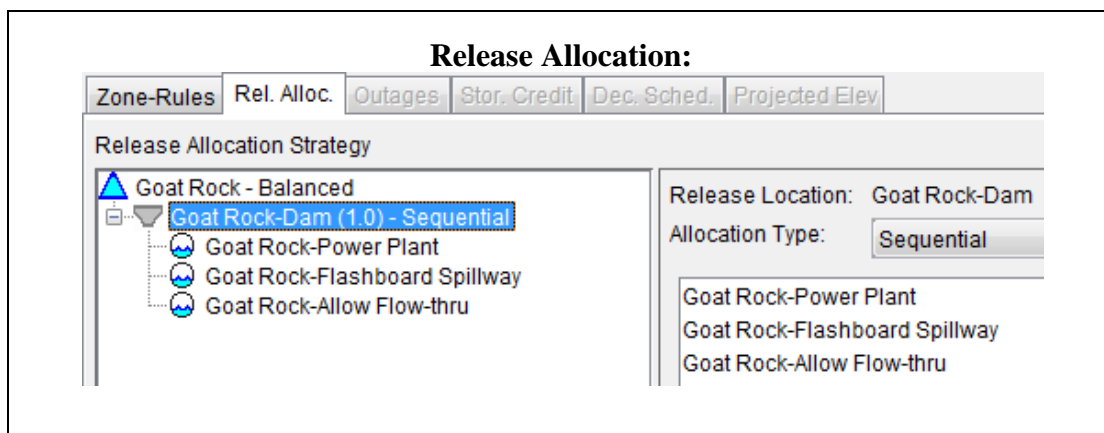


Figure F.20 Goat Rock Reservoir Editor – Network 2014: Operations Tab – Flow-thru Release Allocation

Appendix F – Flow-Thru Reservoirs – Goat Rock

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.

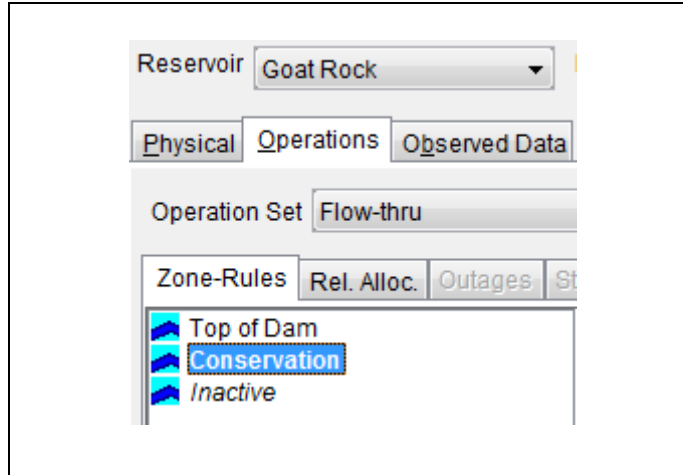


Figure F.21 Goat Rock Reservoir Editor – Network 2014: Operations Tab – *Flow-thru* Zones

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.

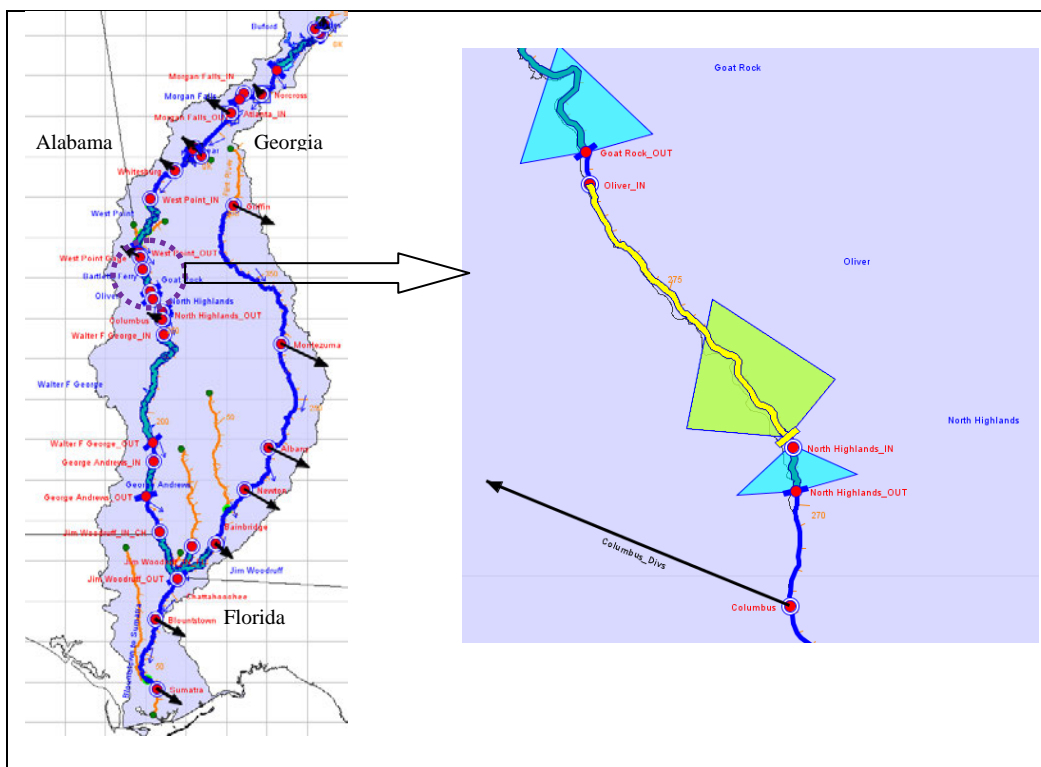


Figure F.22 HEC-ResSim Map Display Showing Location of Oliver

Figure F.23 shows a photo of Oliver Dam.

Appendix F – Flow-Thru Reservoirs – Oliver



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.

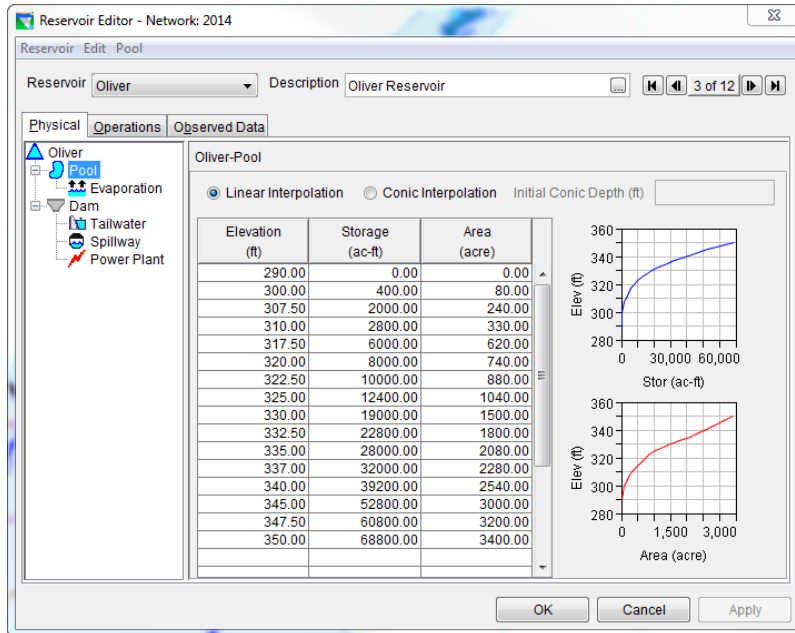


Figure F.24 Oliver Reservoir Editor – Network 2014: Physical Tab – Pool

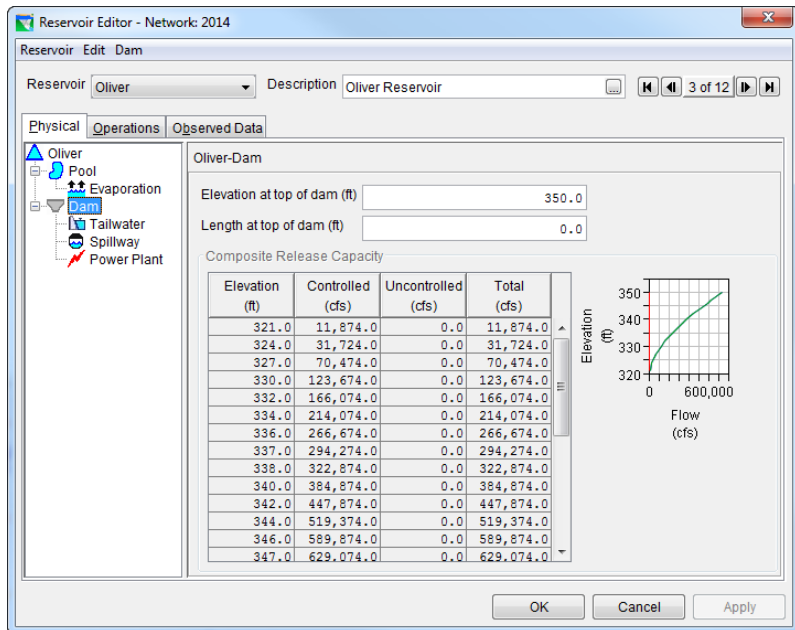


Figure F.25 Oliver Reservoir Editor – Network 2014: Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
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)

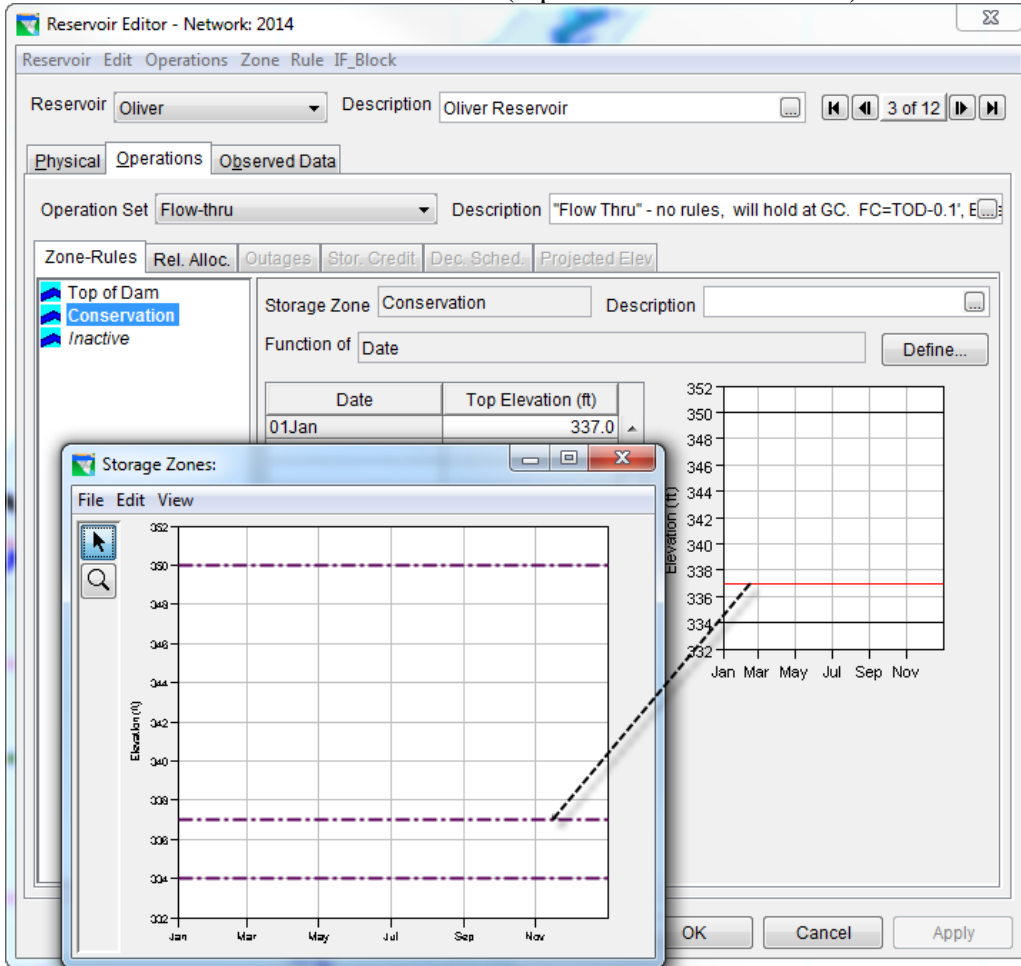


Figure F.26 Oliver Reservoir Editor – Network 2014: Operations Tab – Flow-thru Guide Curve

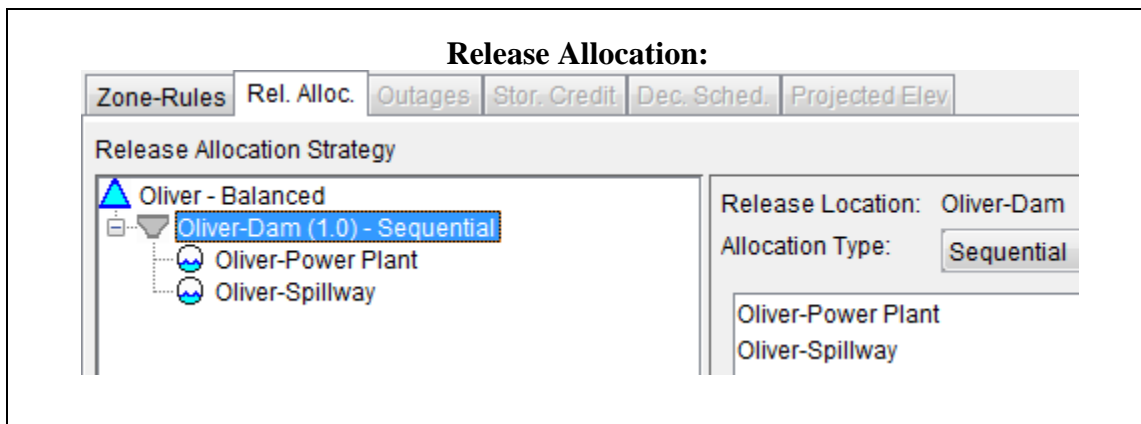


Figure F.27 Oliver Reservoir Editor – Network 2014: Operations Tab – Flow-thru Release Allocation

Appendix F – Flow-Thru Reservoirs – Oliver

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.

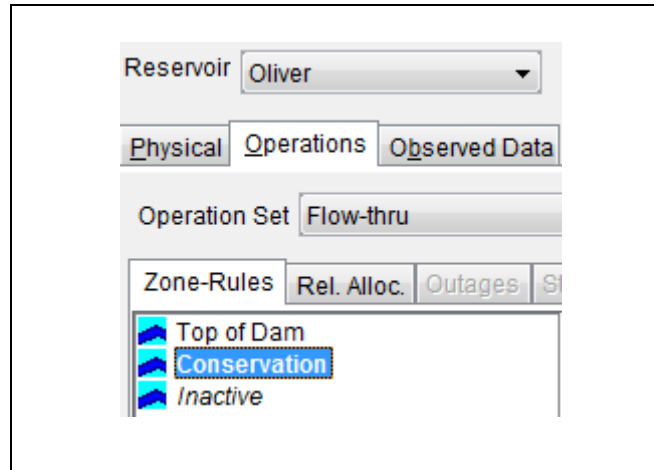


Figure F.28 Oliver Reservoir Editor – Network 2014: Operations Tab –*Flow-thru* Zones

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.

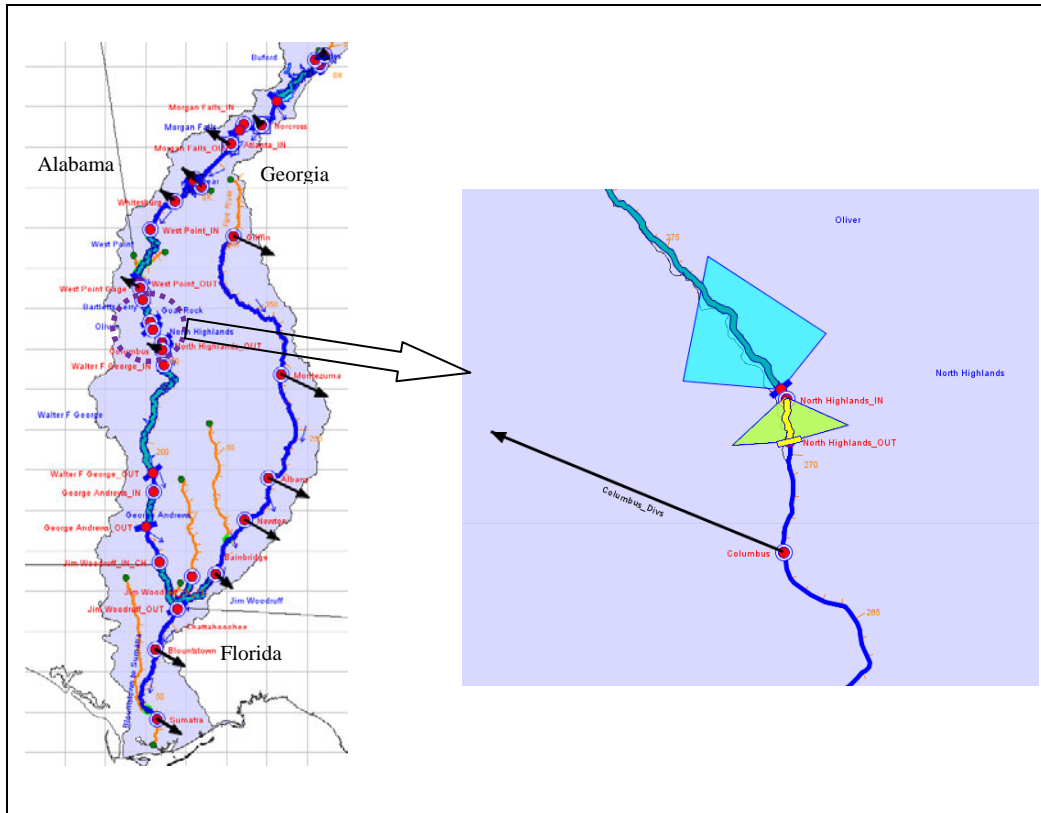


Figure F.29 HEC-ResSim Map Display Showing Location of North Highlands

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

Appendix F – Flow-Thru Reservoirs – North Highlands



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.

Appendix F – Flow-Thru Reservoirs – North Highlands

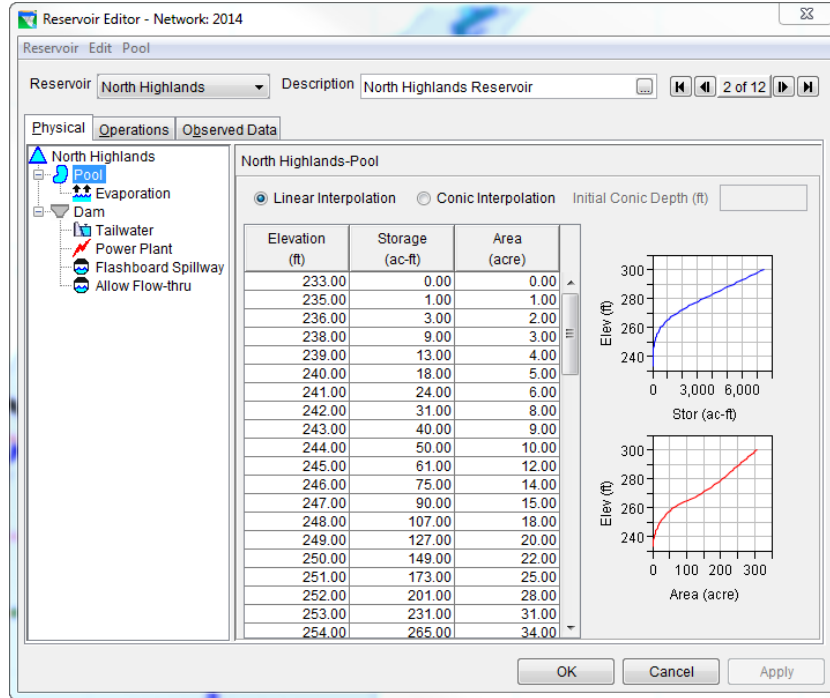


Figure F.30 North Highlands Reservoir Editor – Network 2014: Physical Tab – Pool

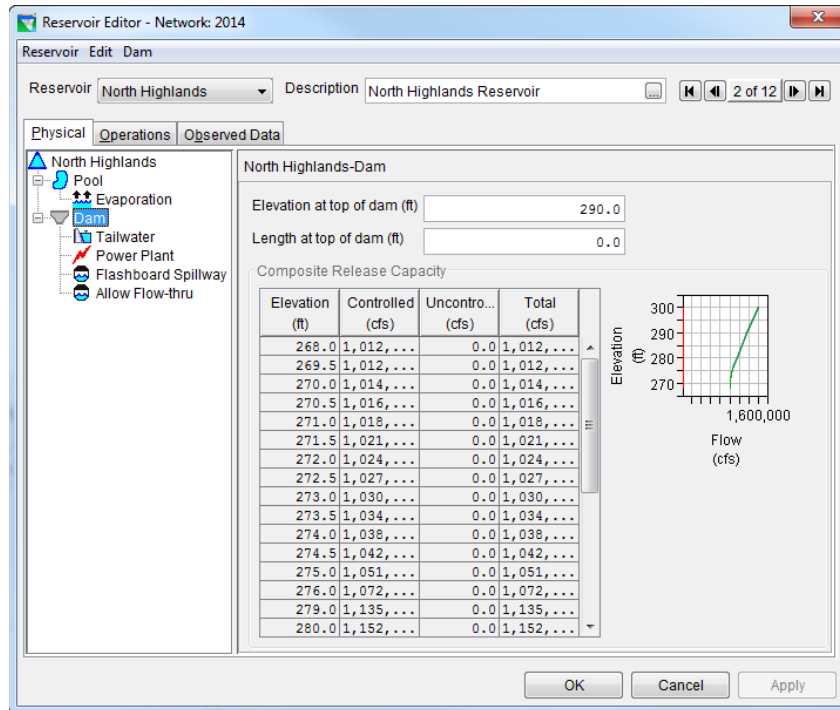


Figure F.31 North Highlands Reservoir Editor – Network 2014: Physical Tab – Dam

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) <small>Blue values = entered into ResSim</small>
Zones	Season = 1Jan - 31Dec
Top of Dam	290
Conservation	269
<i>Inactive</i>	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)

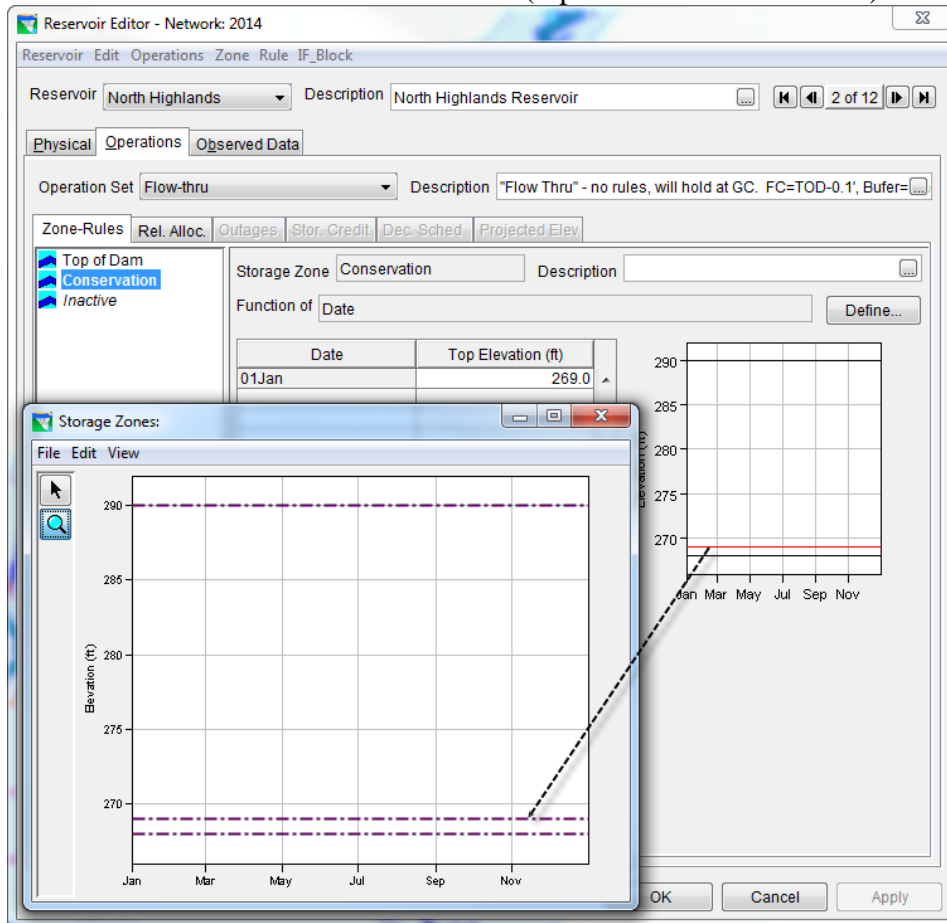


Figure F.32 North Highlands Reservoir Editor – Network 2014: Operations Tab – Flow-thru Guide Curve

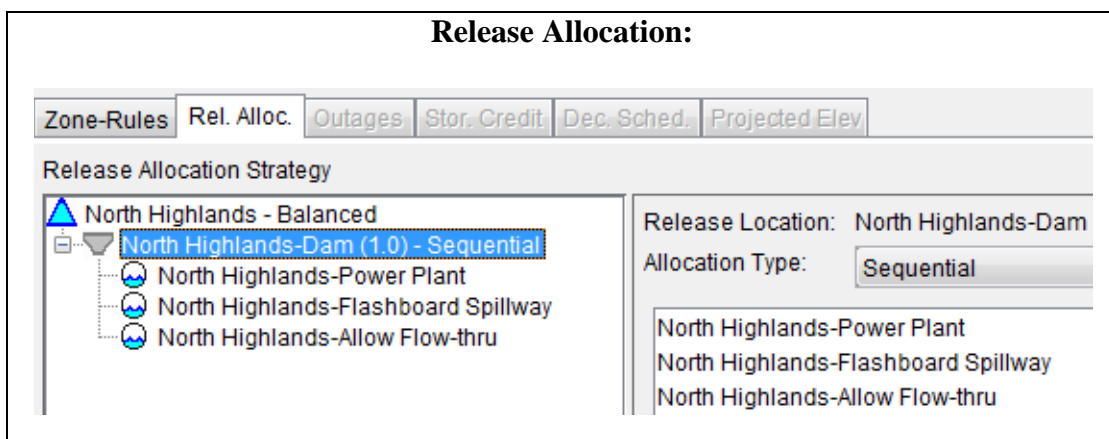


Figure F.33 North Highlands Reservoir Editor – Network 2014: Operations Tab – Flow-thru Release Allocation

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.

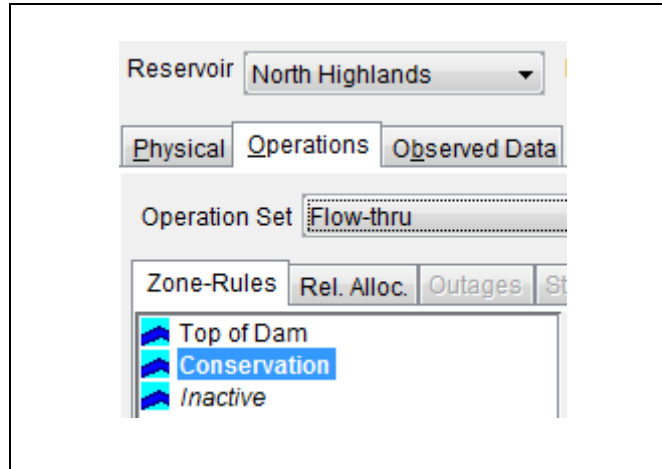


Figure F.34 North Highlands Reservoir Editor – Network 2014:Operations Tab – *Flow-thru* Zones

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Appendix G – Proposed Reservoirs

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“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.

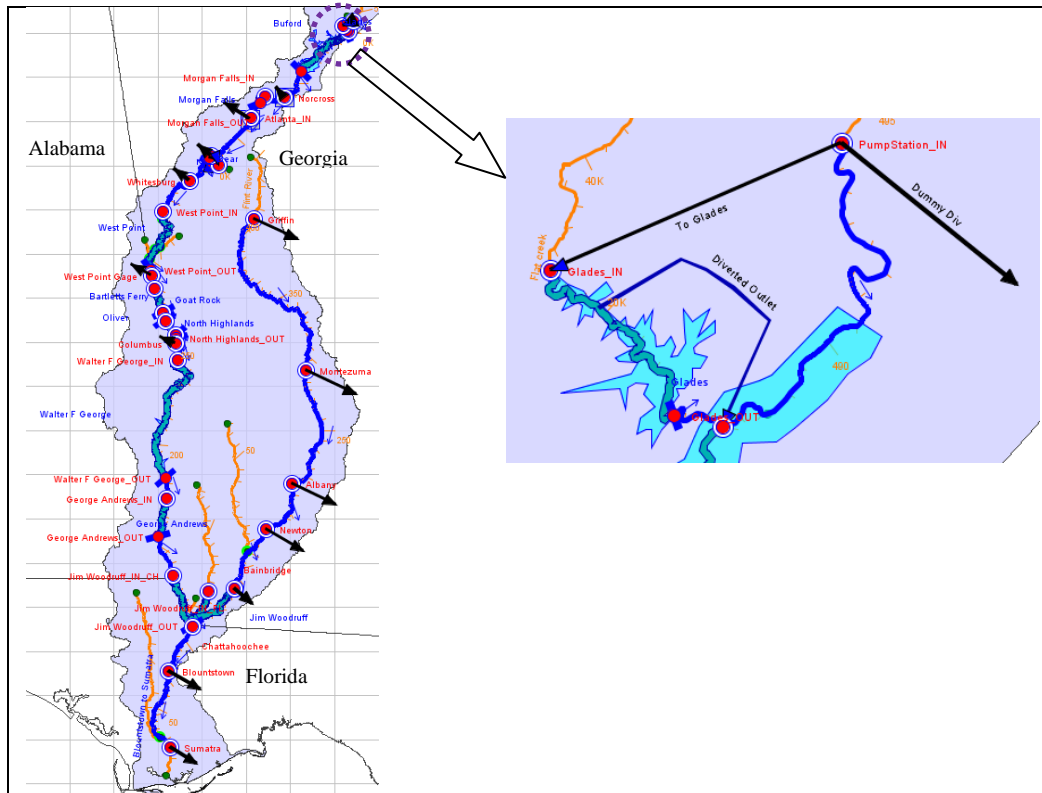


Figure G.01 HEC-ResSim Map Display Showing Location of Glades

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.

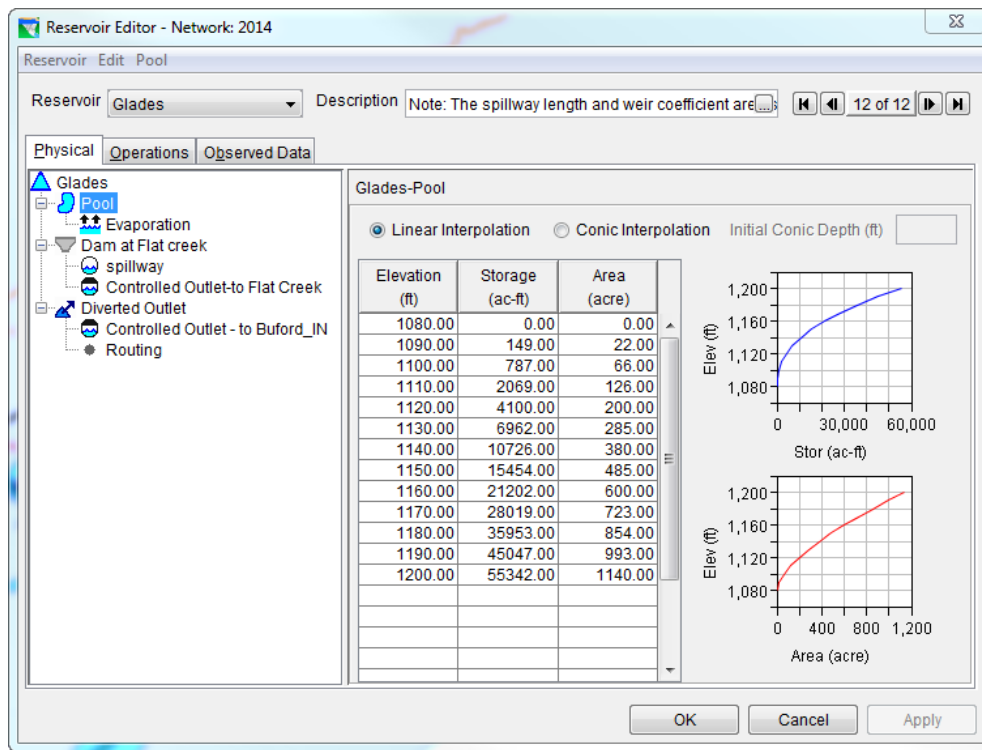


Figure G.02 Glades Reservoir Editor – Network 2014: Physical Tab – Pool

Appendix G – Proposed Reservoirs

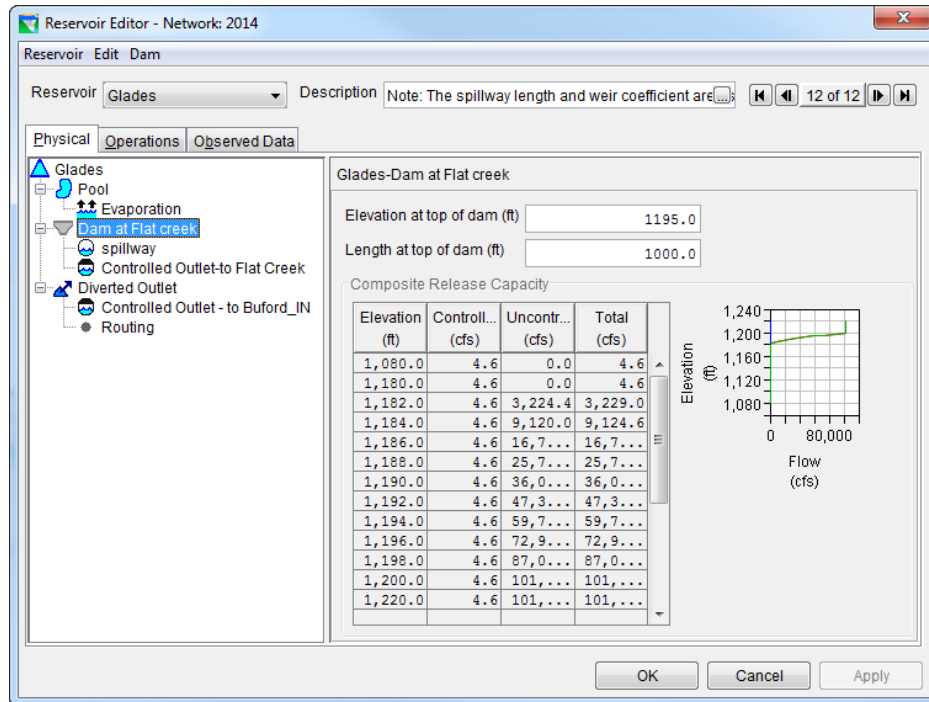


Figure G.03 Glades Reservoir Editor – Network 2014: Physical Tab – Dam

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)
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)

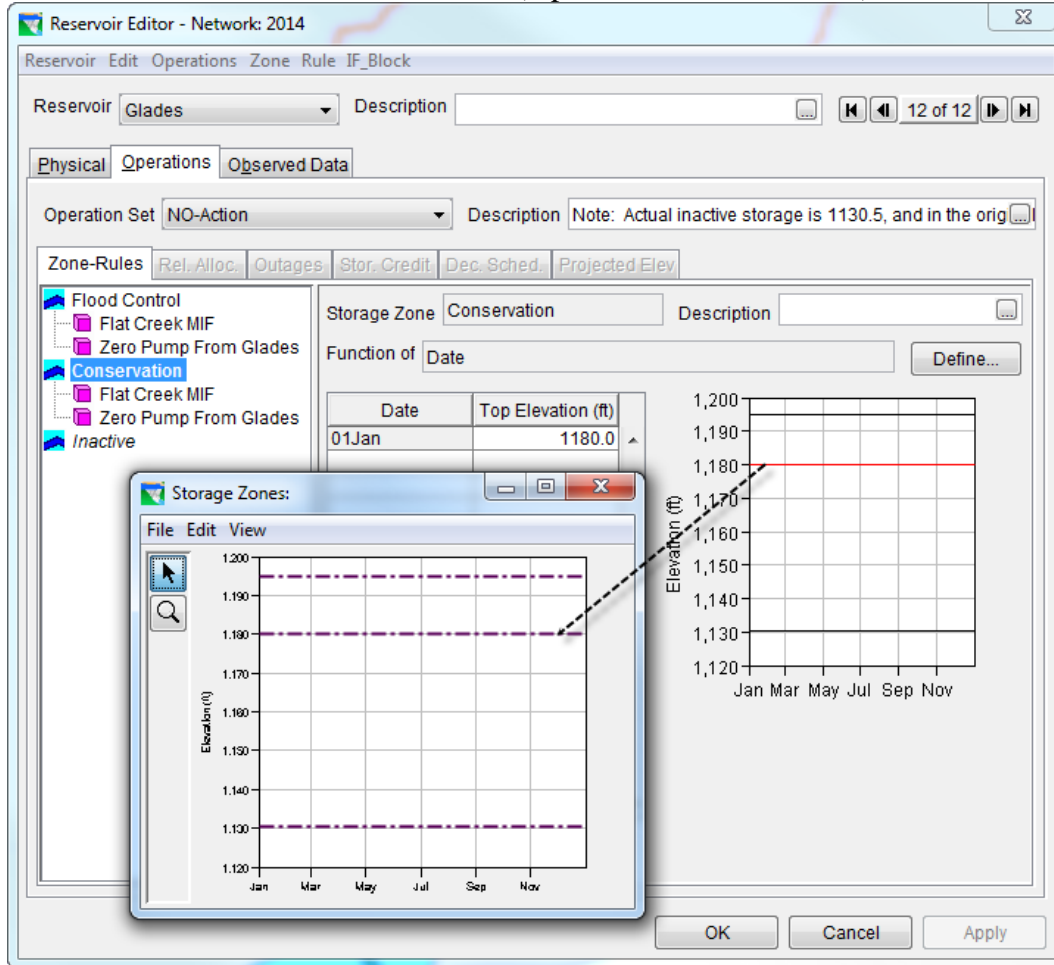


Figure G.04 Glades Reservoir Editor – Operations Tab – “NO-Action” Guide Curve

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.

Appendix G – Proposed Reservoirs

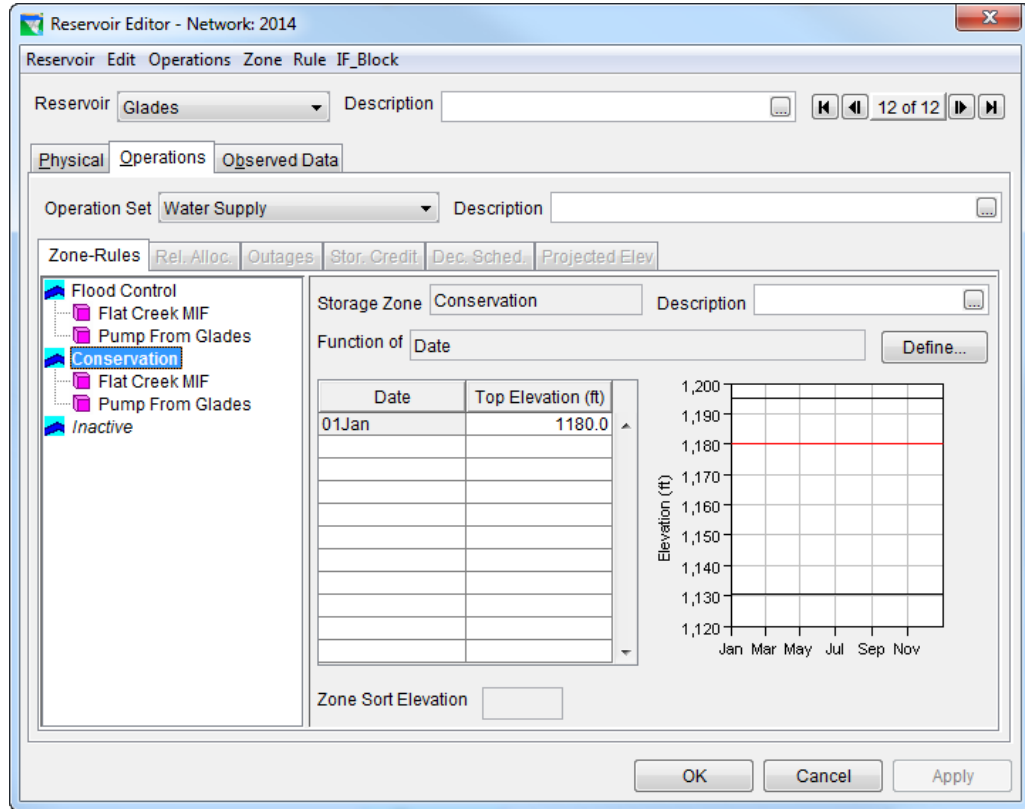


Figure G.05 Glades Reservoir Editor – Operations Tab – “Water Supply” Guide Curve

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.

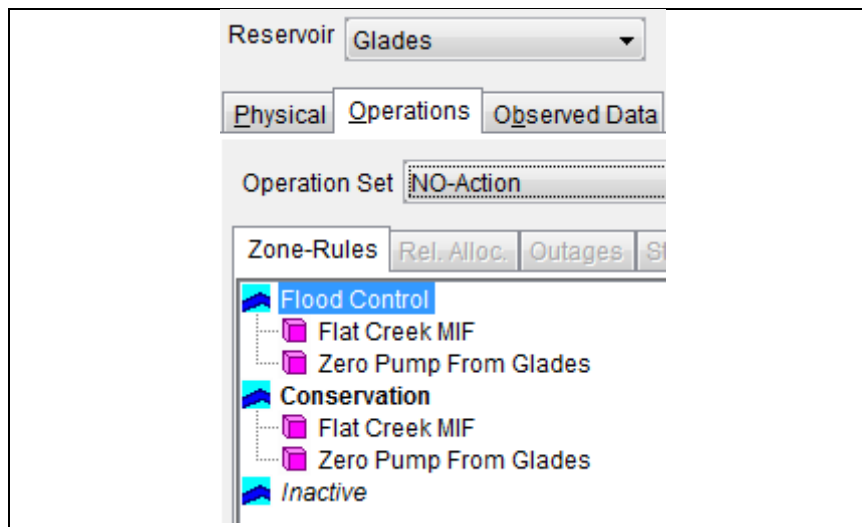


Figure G.06 Glades Reservoir – “NO-Action” Operation Set, Zones

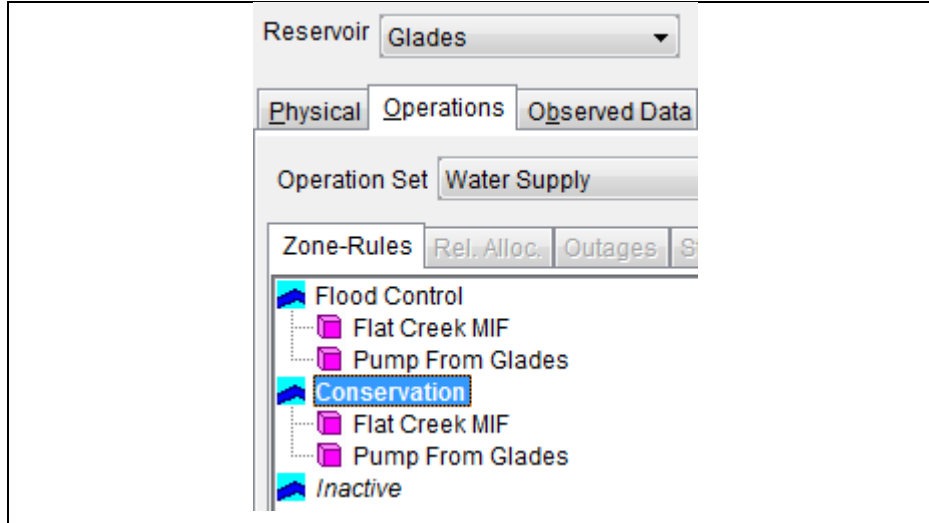


Figure G.07 Glades Reservoir – “Water Supply” Operation Set, Zones

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.

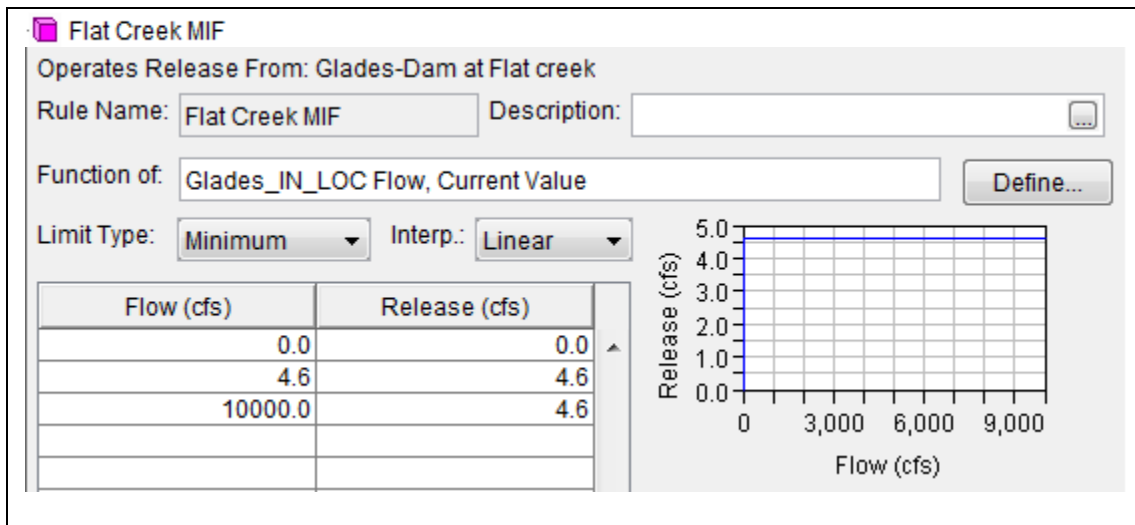


Figure G.08 Glades Reservoir – Flat Creek MIF rule

Appendix G – Proposed Reservoirs

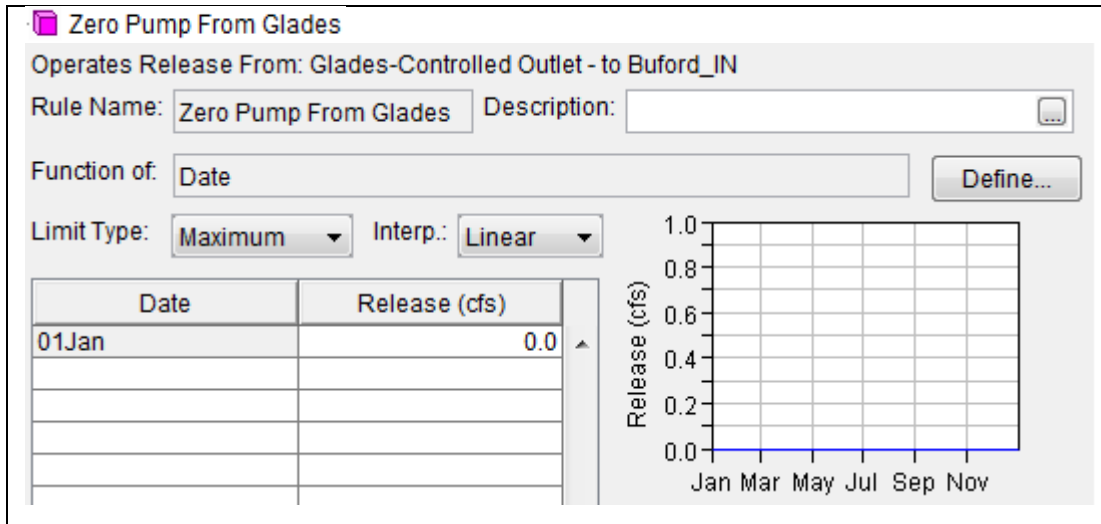


Figure G.09 Glades Reservoir – Zero Pump From Glades rule

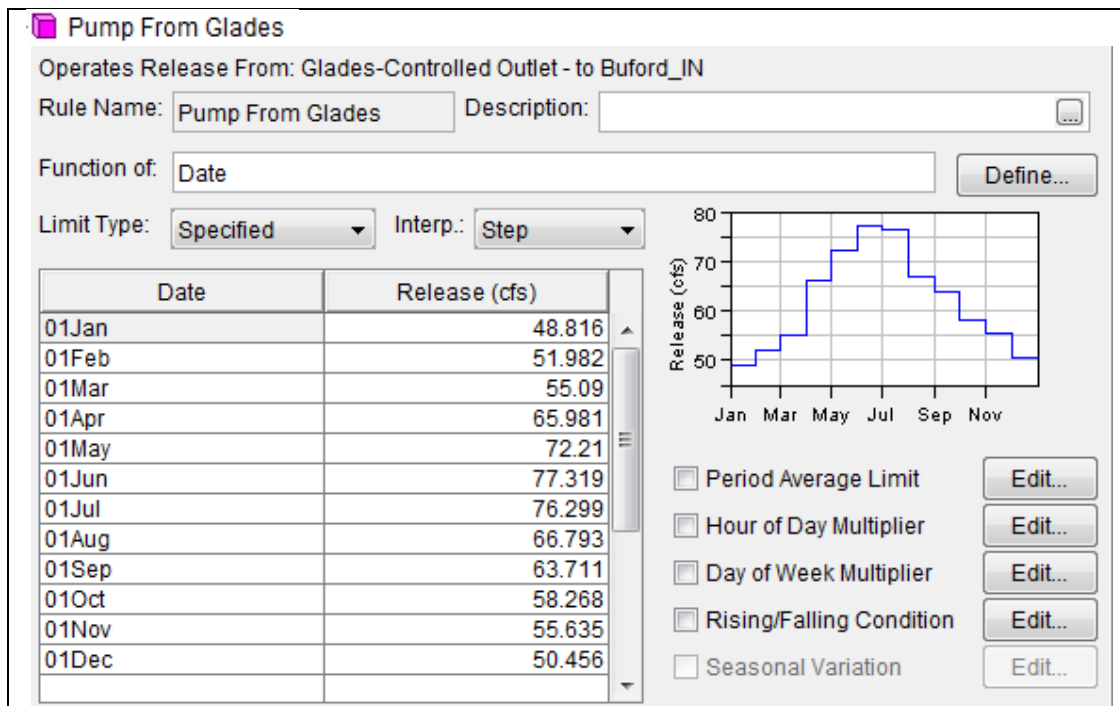


Figure G.10 Glades Reservoir –Pump From Glades rule

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.

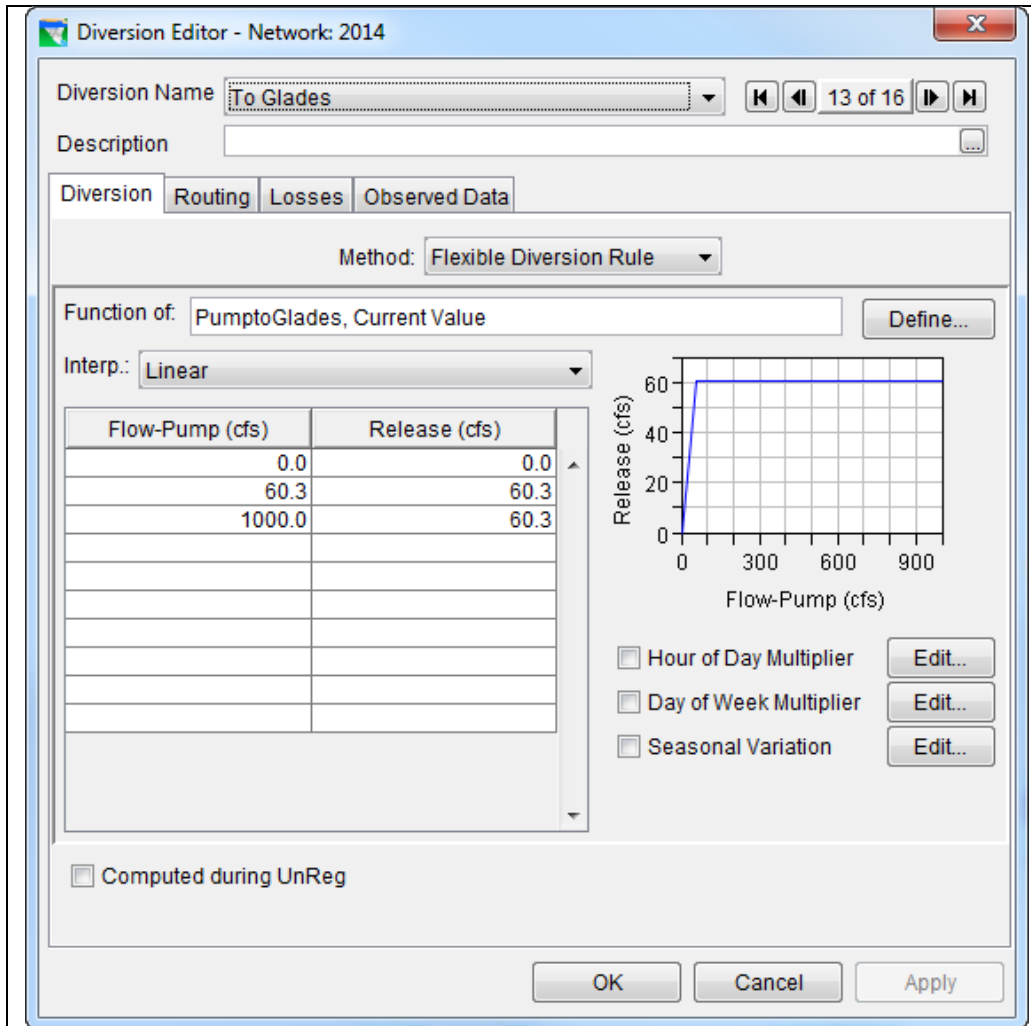


Figure G.11 Diversion Editor – Network 2014: To Glades

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.

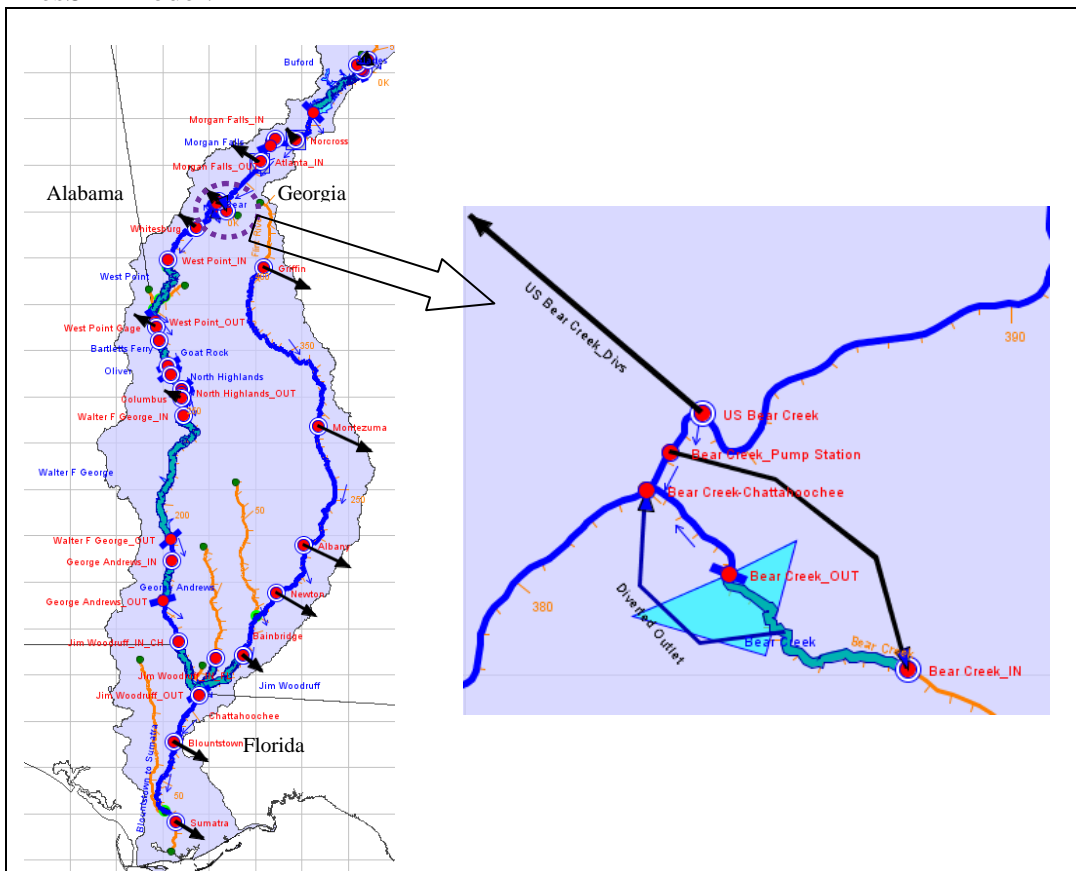


Figure G.12 HEC-ResSim Map Display Showing Location of Bear Creek Reservoir

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.

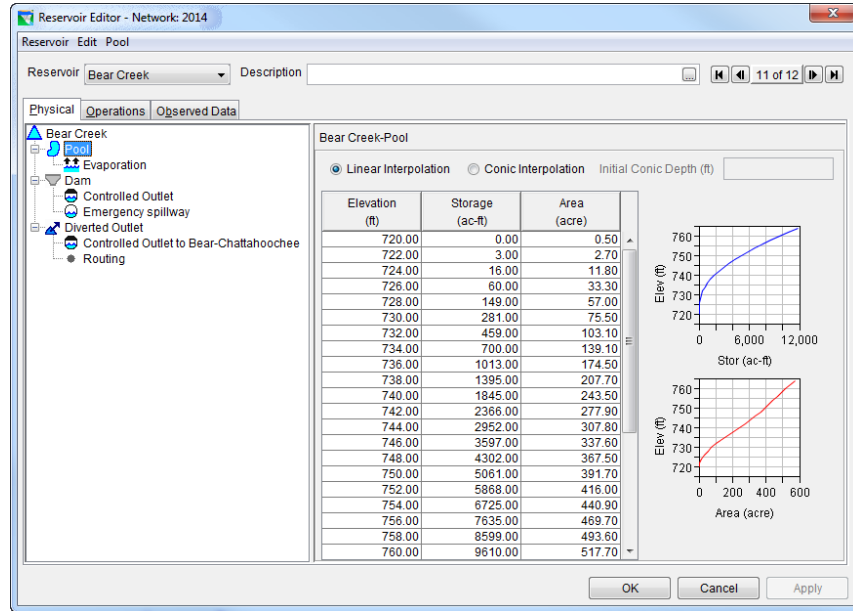


Figure G.13 Bear Creek Reservoir Editor – Network 2014: Physical Tab – Pool

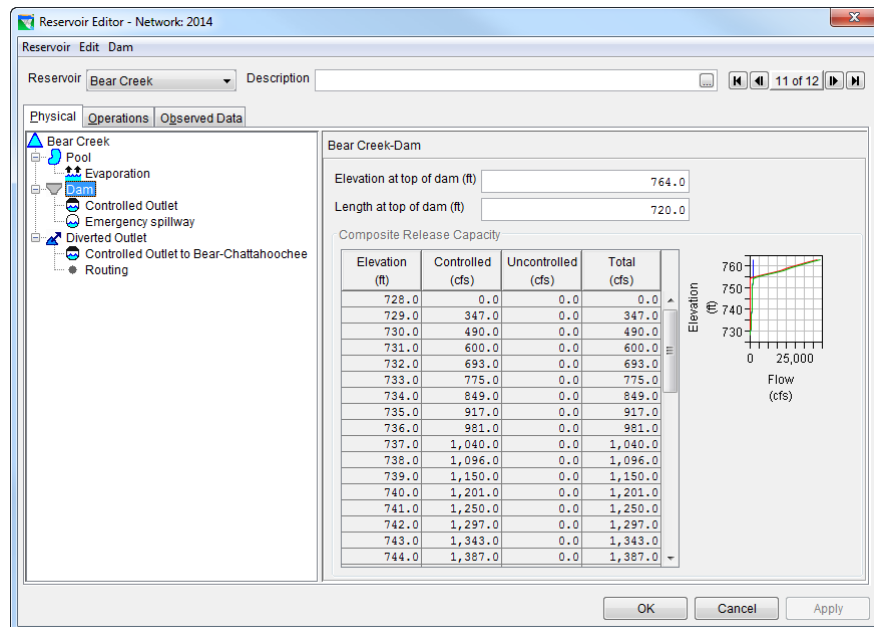


Figure G.14 Bear Creek Reservoir Editor – Network 2014: Physical Tab – Pool

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”

Appendix G – Proposed Reservoirs

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)
Zones	Season = 1Jan - 31Dec <small>Blue values = entered into ResSim</small>
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)

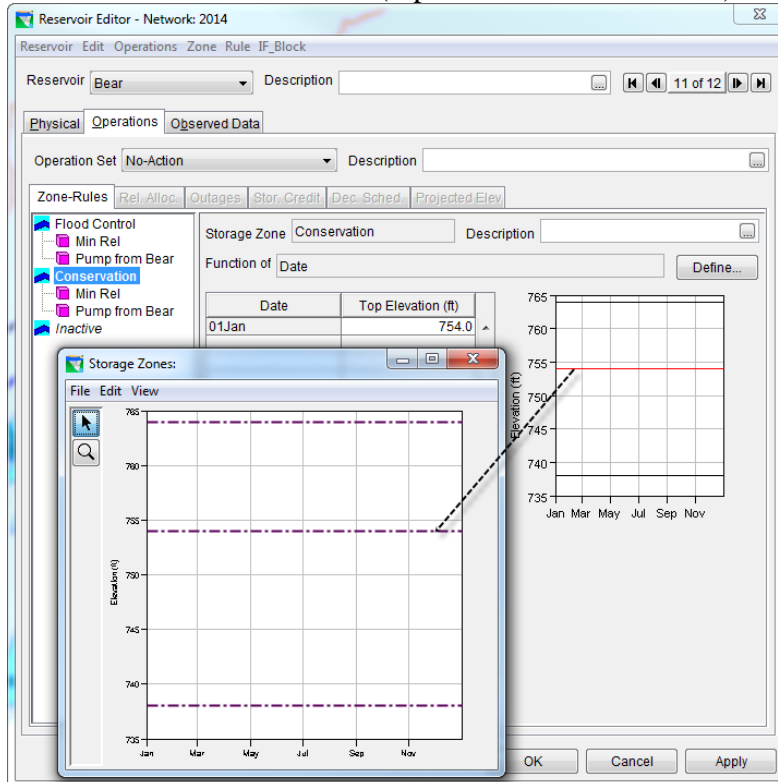


Figure G.15 Bear Reservoir Editor – Network 2014: Operations Tab – “NO-Action” Guide Curve

2. Rule Illustration

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

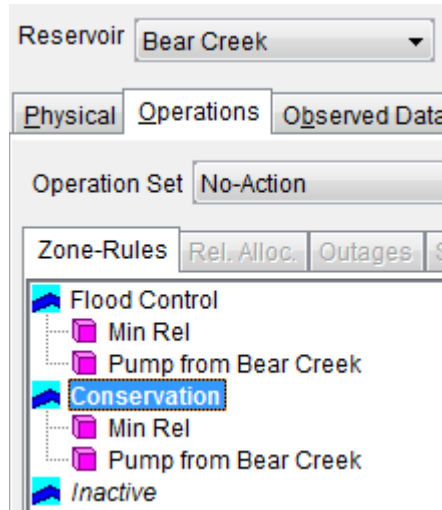


Figure G.16 Bear “NO-Action” OpSet, Zones

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.

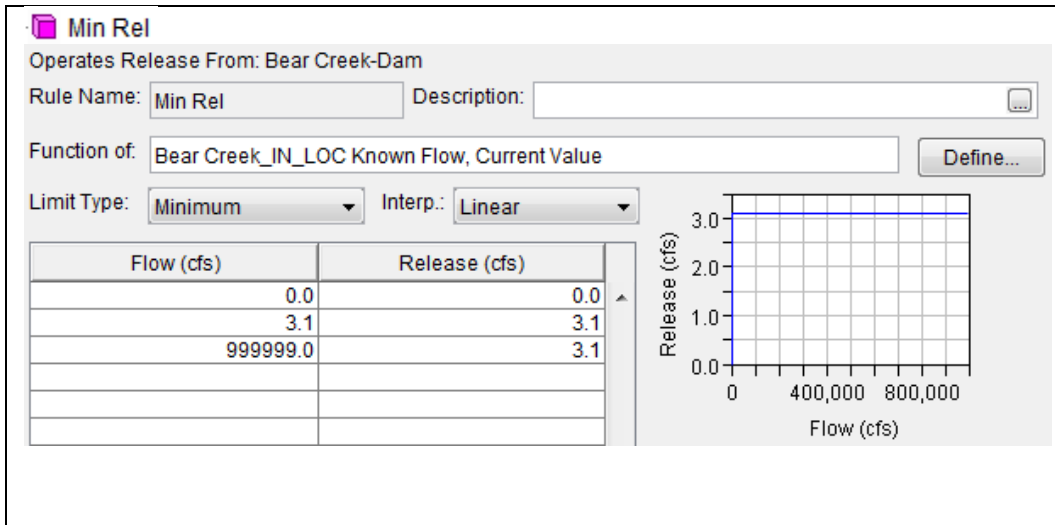


Figure G.17 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Min Rel

Appendix G – Proposed Reservoirs

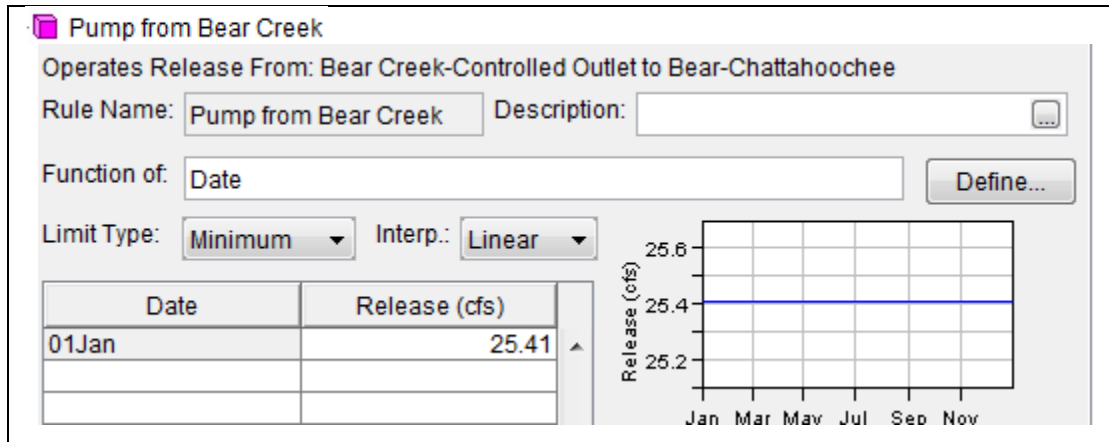


Figure G.18 Reservoir Editor – Network 2014: Operations Tab – NO-Action OpSet – Pump from Bear

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).

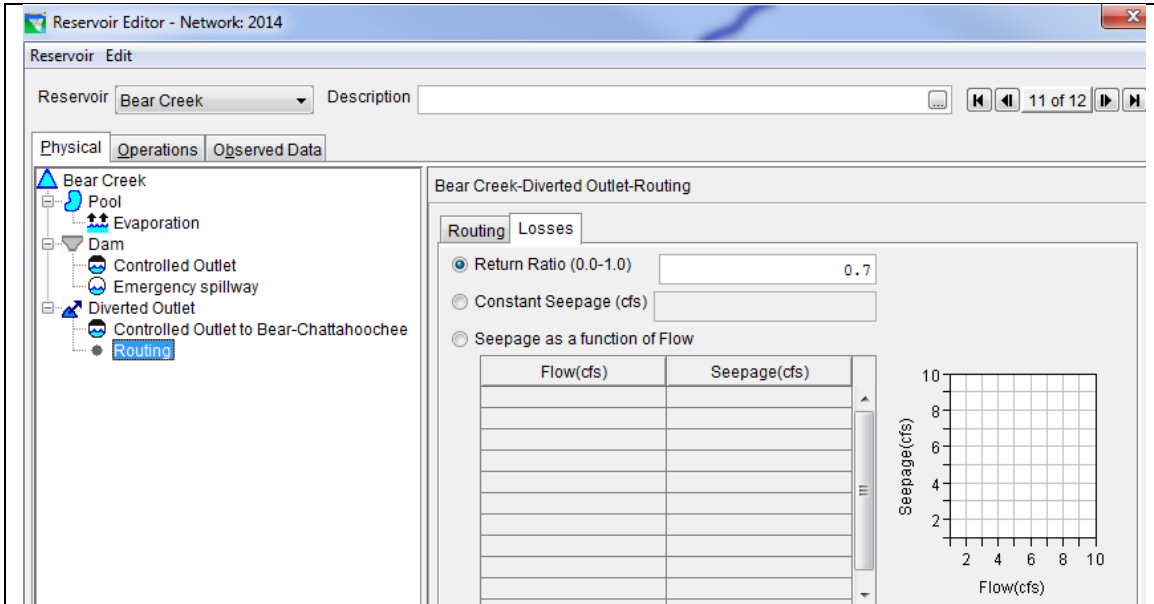


Figure G.19 Bear Reservoir Editor –Physical Tab – Bear – Diverted Outlet - Routing

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.

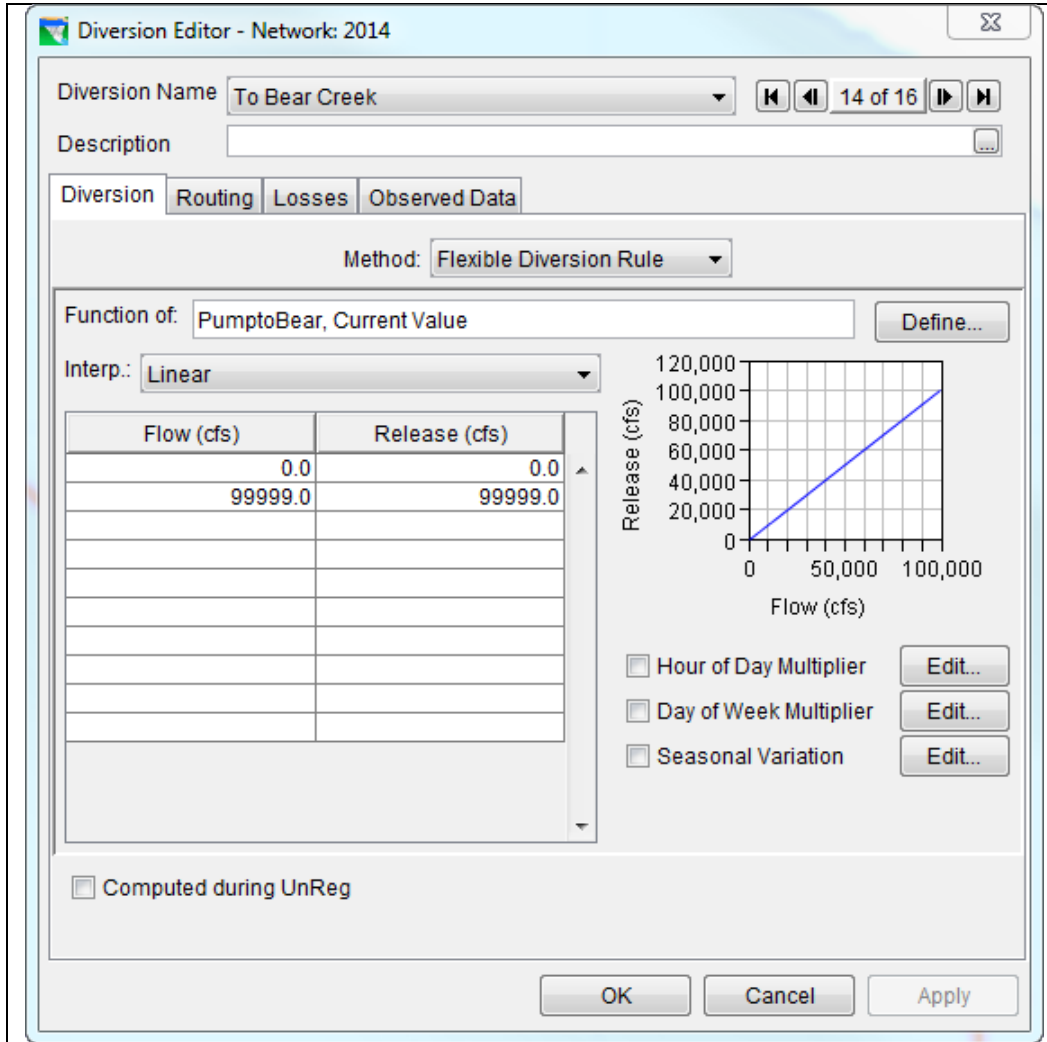


Figure G.20 Diversion Editor – Network 2014: To Bear

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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Appendix H – State Variables and Utility Scripts

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 referred to as “Master” state variables and the additional state variables computed there-in are referred 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,

Appendix H – State Variables and Utility Scripts

“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.

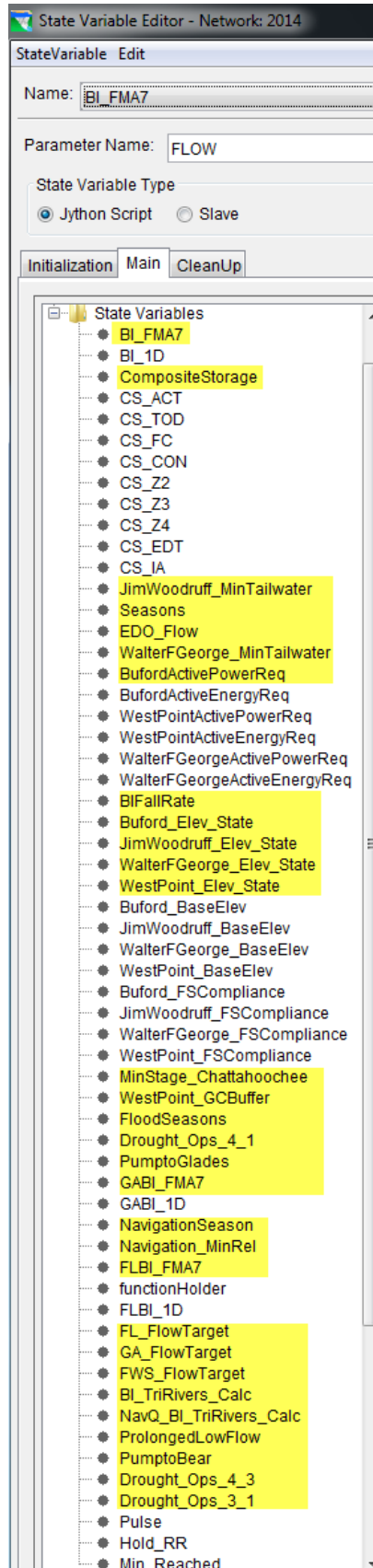


Figure H.01 List of State Variables in the ACF Basin Model

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	$\geq 34,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 16,000$ and < 34,000	$\geq 16,000 + 50\% \text{ BI} > 16,000$	Up to 50% BI > 16,000
		$\geq 5,000$ and < 16,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
	Zone 3	$\geq 39,000$	$\geq 25,000$	Up to 100% BI > 25,000
		$\geq 11,000$ and < 39,000	$\geq 11,000 + 50\% \text{ BI} > 11,000$	Up to 50% BI > 11,000
		$\geq 5,000$ and < 11,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
June – November	Zones 1, 2, and 3	$\geq 22,000$	$\geq 16,000$	Up to 100% BI > 16,000
		$\geq 10,000$ and < 22,000	$\geq 10,000 + 50\% \text{ BI} > 10,000$	Up to 50% BI > 10,000
		$\geq 5,000$ and < 10,000	$\geq \text{BI}$	
		< 5,000	$\geq 5,000$	
December – February	Zones 1, 2, and 3	$\geq 5,000$	$\geq 5,000$ (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	$\geq 5,000$	
At all times	Zone 4	NA	$\geq 5,000$	Up to 100% BI > 5,000
At all times	Drought Zone	NA	$\geq 4,500$	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 storage 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 defined 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

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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.

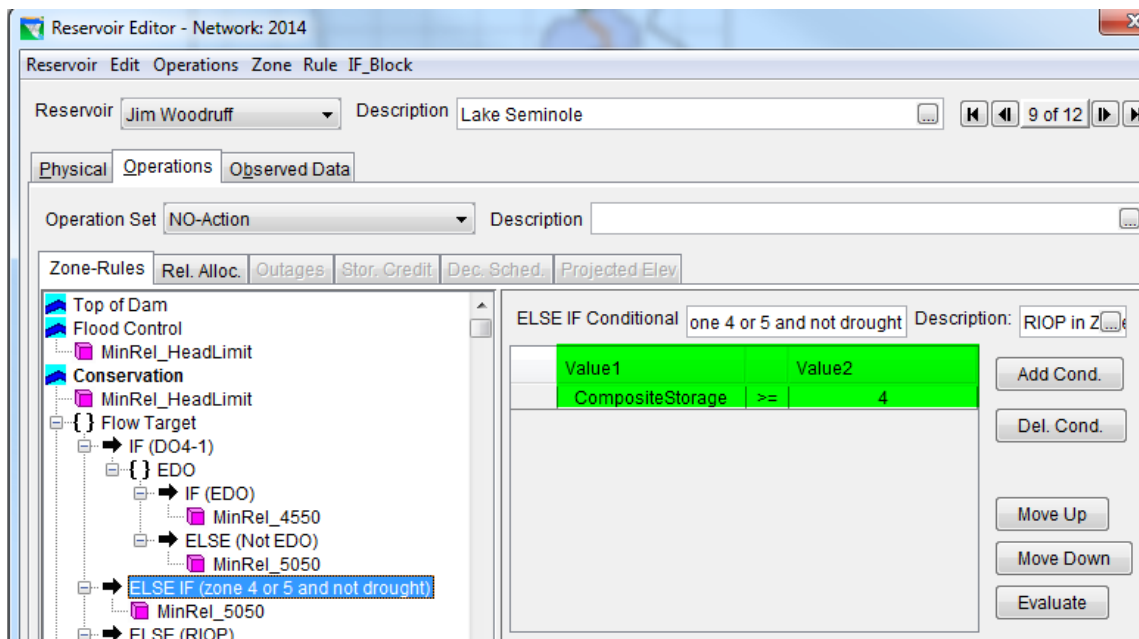


Figure H.02 Example of Applying State Variable “CompositeStorage”

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

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day of a month). Figure H.03 shows the Drought Composite Triggers in “Drought_Ops_4_1” state variable.

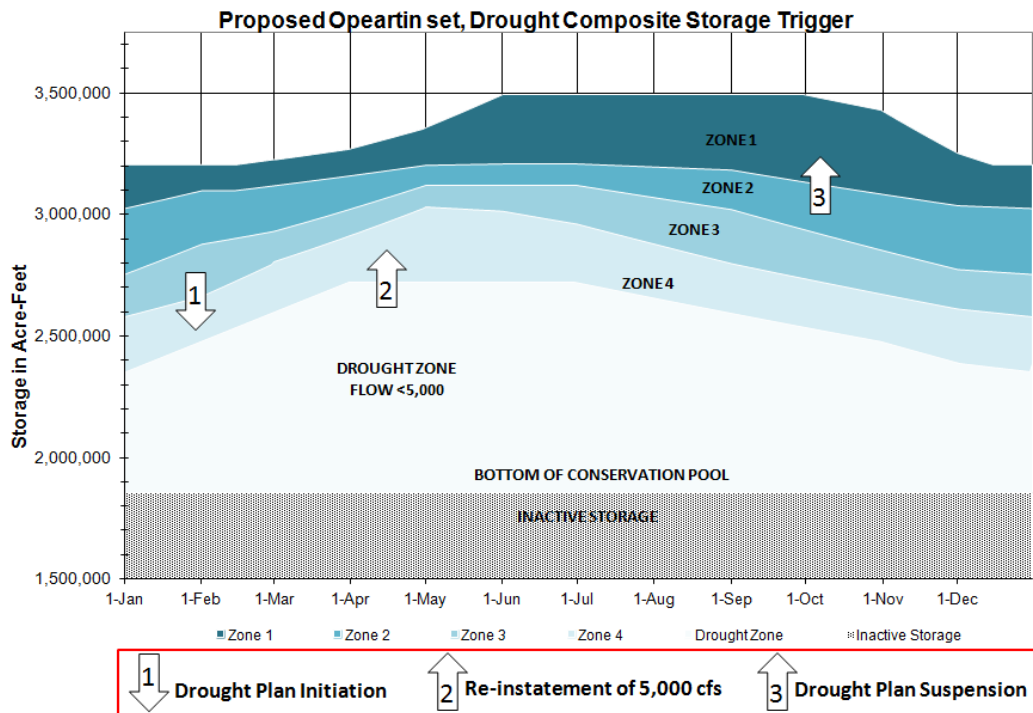


Figure H.03 Drought Composite Storage Triggers in State Variable “Drought_Ops_4_1”

- *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 Composite Storage Zone 3 or higher, then Drought_Ops_4_3=false and EDO_Flow=false.

Figure H.04 shows the Drought Composite Triggers in “Drought_Ops_4_3” state variable.

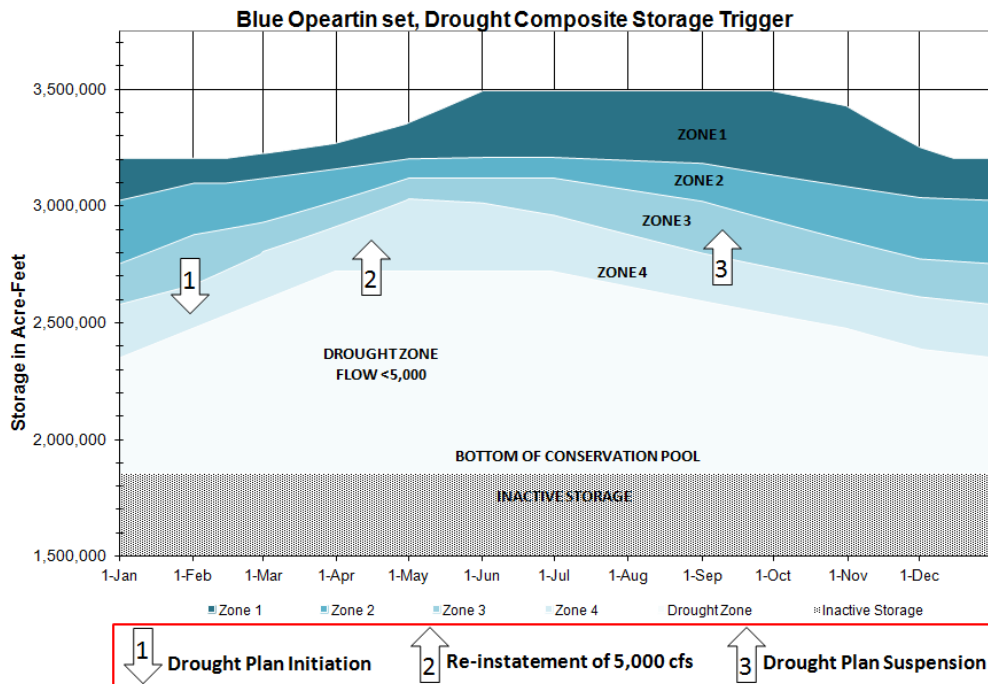


Figure H.04 Drought Composite Storage Triggers in State Variable “Drought_Ops_4_3”

- *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 Drought_Ops_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 “Drought_Ops_3_1” state variable.

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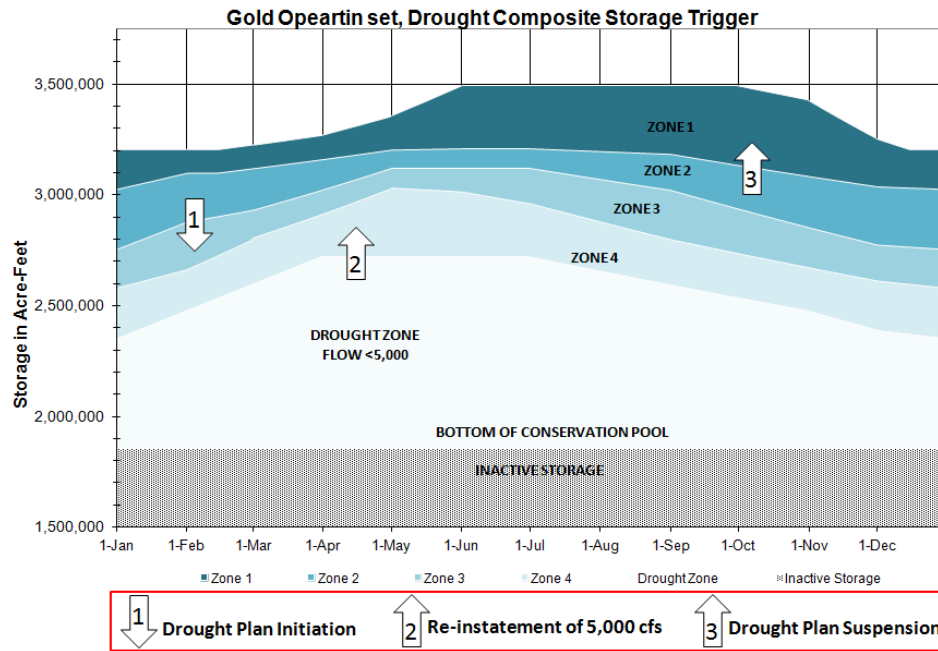


Figure H.05 Drought Composite Storage Triggers in State Variable “Drought_Ops_3_1”

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.

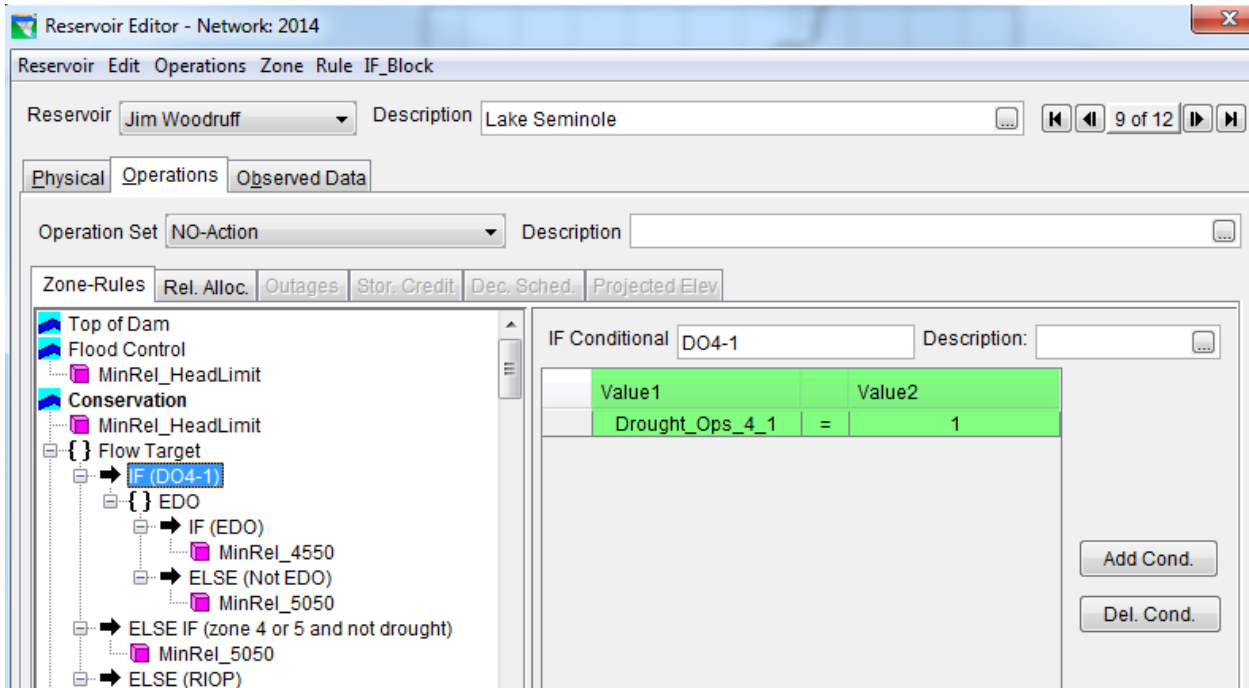


Figure H.06 Example of Applying State Variable “Drought_Ops_4_1”

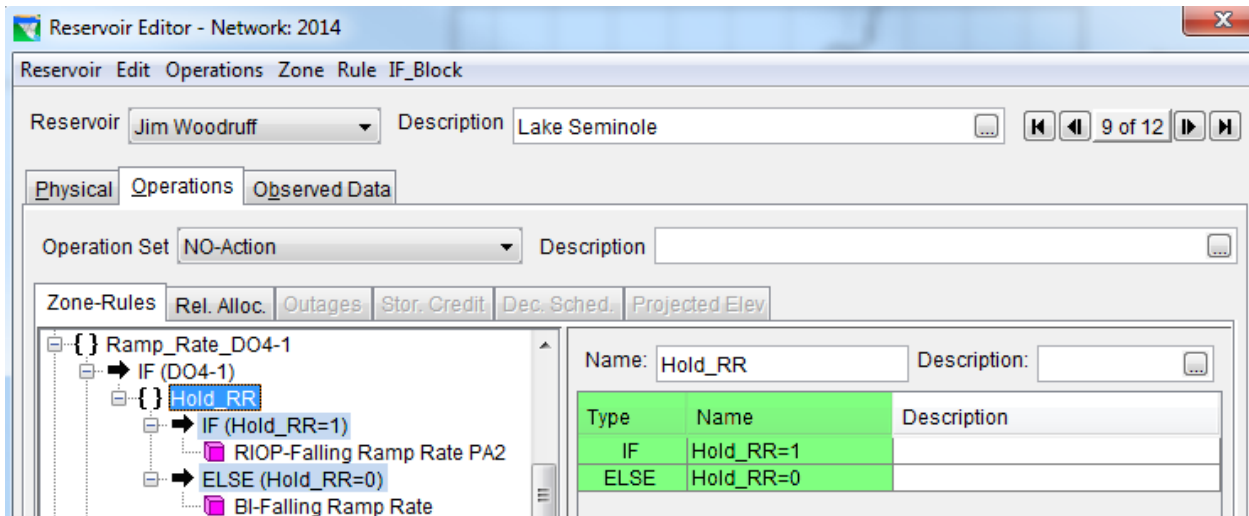


Figure H.07 Example of Applying State Variable “Hold_RR”

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.

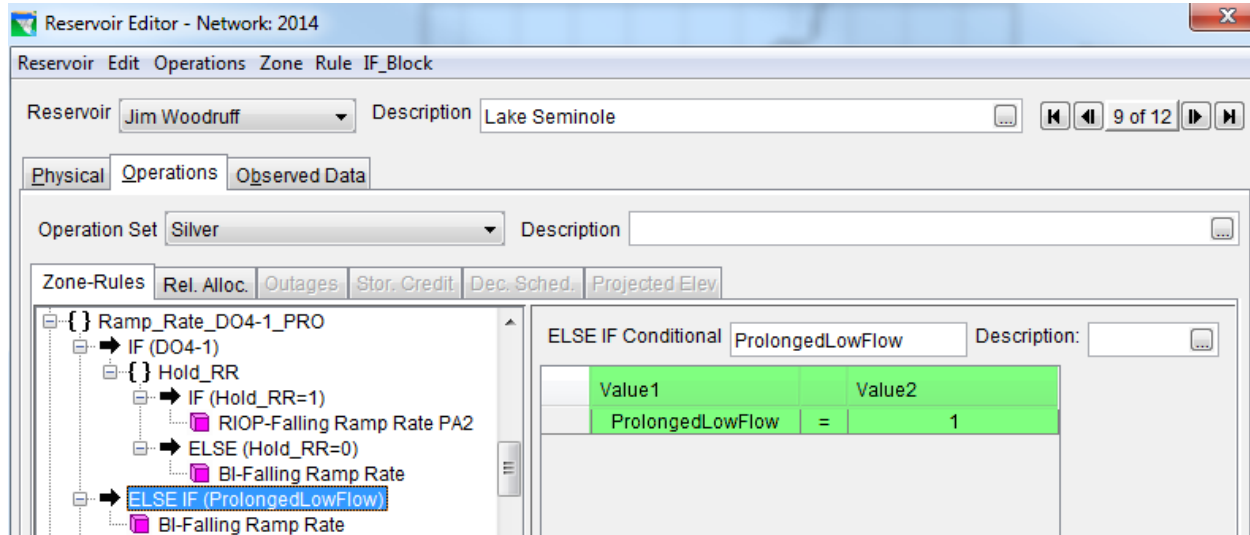


Figure H.08 Example of Applying State Variable “ProlongedLowFlow”

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.

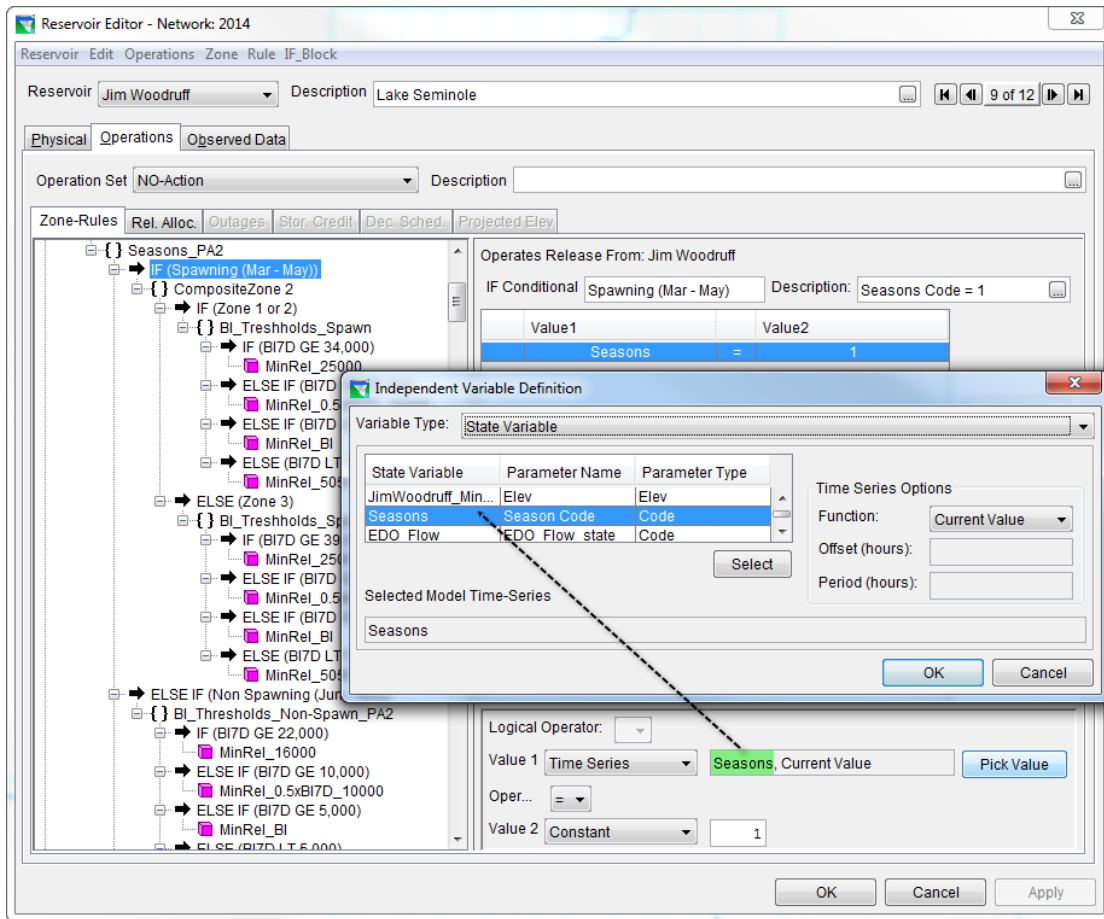


Figure H.09 Example of Applying State Variable “Seasons”

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.

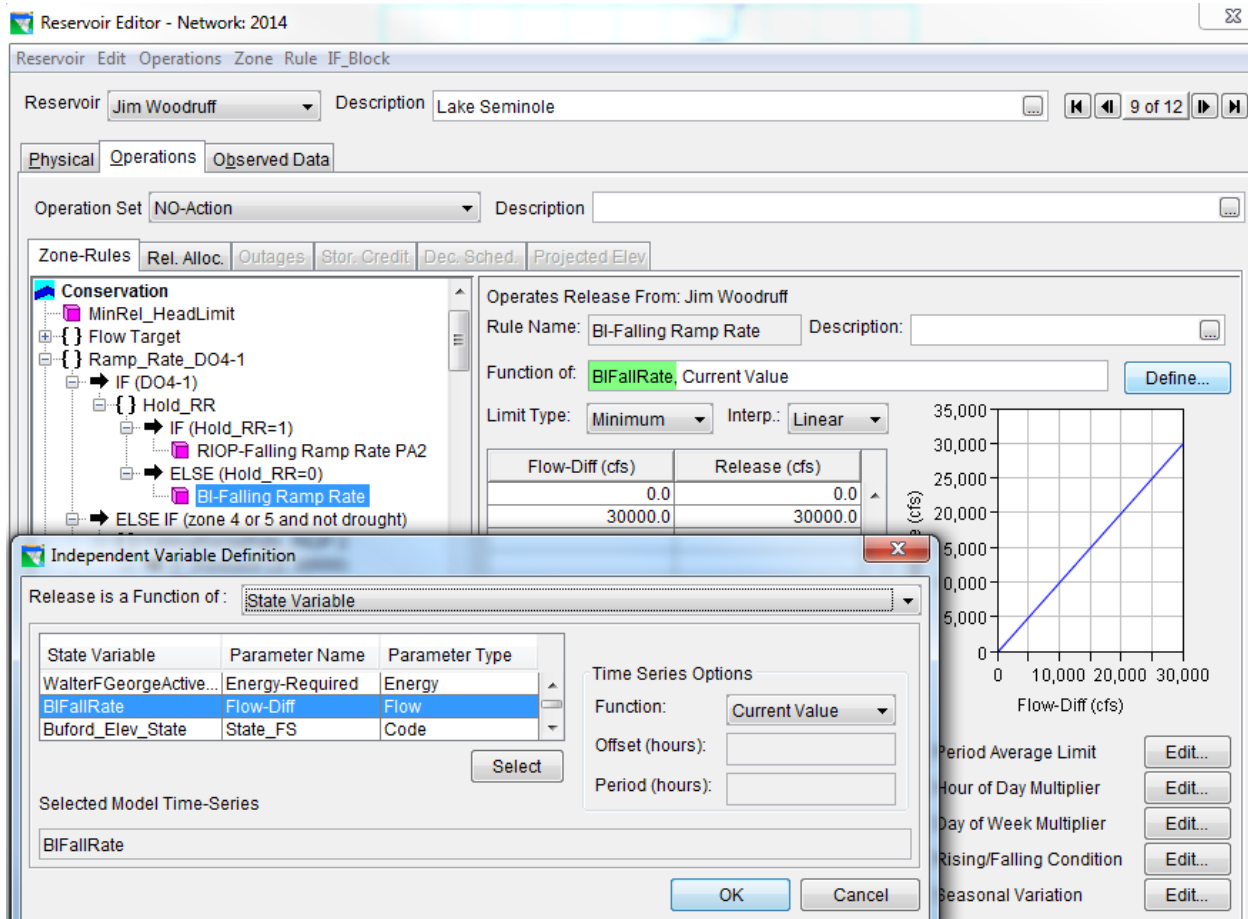


Figure H.10 Example of Applying State Variable “BIFallRate”

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 of the “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.

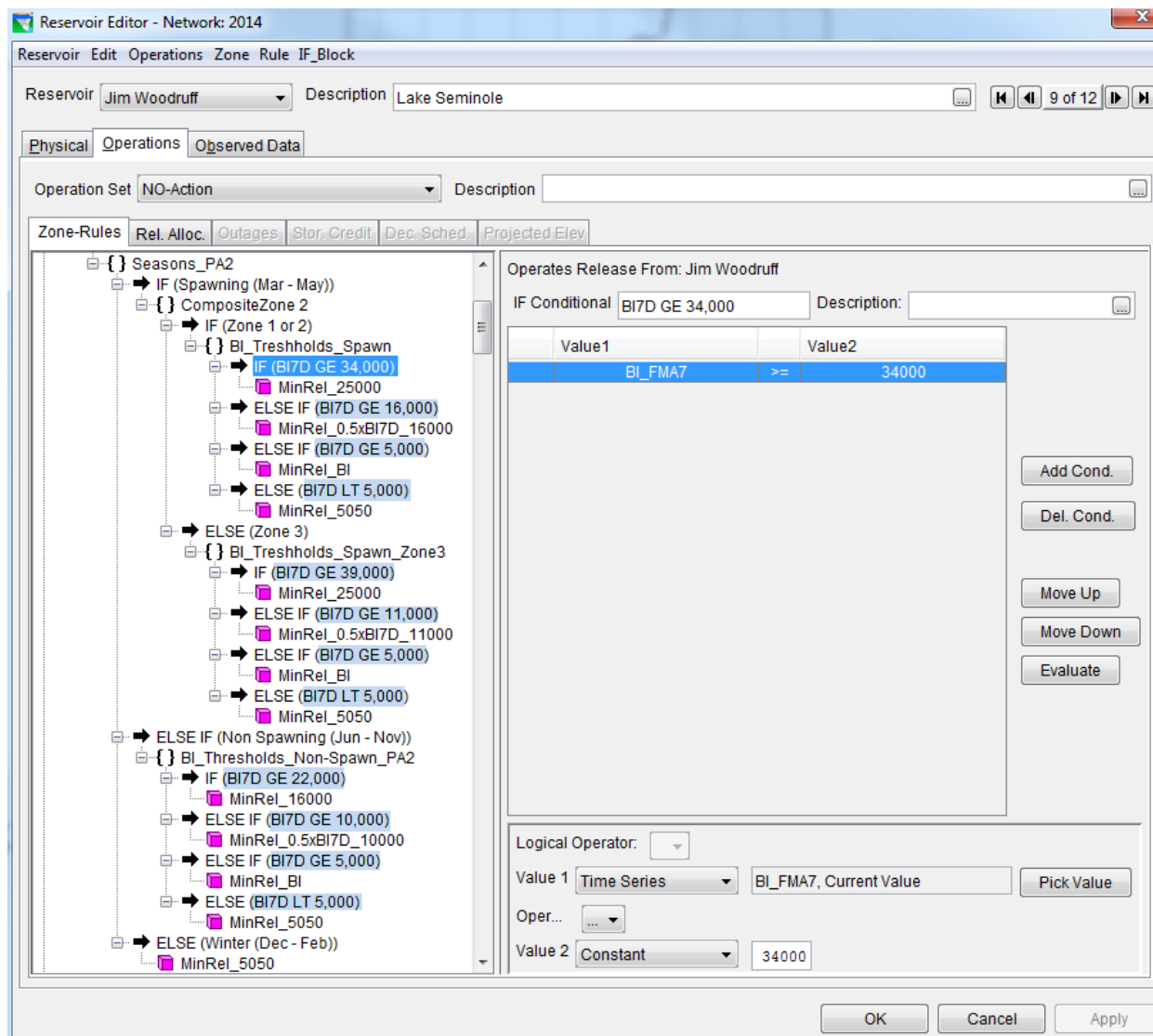


Figure H.11 Example of Applying State Variable “BI_FMA7”

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:

$$\text{Basin Inflow} = \text{Chattahoochee River flow} + \text{Lanier change in storage} + \text{West Point change in storage} + \text{WF George change in storage} + \text{Jim Woodruff change in storage}$$

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.

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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 composite 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 checked whether it is less than 6,000 cfs or not. If BI7D is greater than 10,000 cfs and Chatt_state_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	<u>Mar-Nov</u> : 50% of any RBI-P7 that exceeds minimum flow <u>Dec-Feb</u> : 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 included 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.

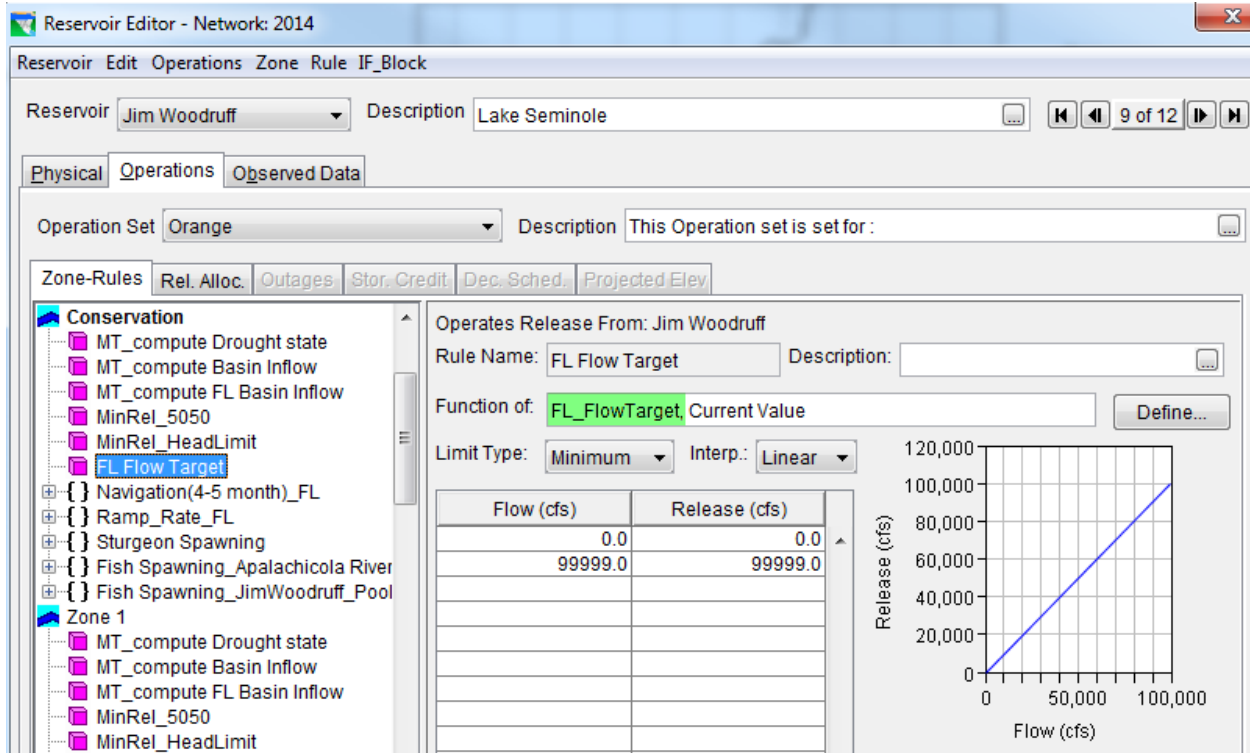


Figure H.12 Example of Applying State Variable “FL_FlowTarget”

10. GA_FlowTarget

The operational requirements for Georgia alternative is represented in Table 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 Woodruff based on the conditions that are shown in Table H.05.

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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	$\geq 6,500$	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 $Q = \min(10,500, \min(\text{observed moving 30-day flow}))$	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if $BI \geq 10,500$ If $BI < 10,500$ and $\geq 5,000$ If $BI < 5,000$	$\geq 10,500$ $\geq BI$ $\geq 5,000$	
In sub-period April 16- April 30		Lanier $> 1066'$, and West Point $> 632'$, and Walter F George $> 187'$	Maintain $Q = \min(22,500, \max(10,500, \min(\text{observed March 17-April 15 daily flow}))$	Entire or partial BI above SLF, subject to available Storage capacity
June- Nov	Zone 1,2, and 3	$BI \geq 10476$ & previous seven day's Chattahoochee gage flow < 5100	\geq 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
		$BI \geq 7181$ and < 10476 & previous seven day's Chattahoochee gage flow < 5100	\geq 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	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	$\geq 4,500$	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.

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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.

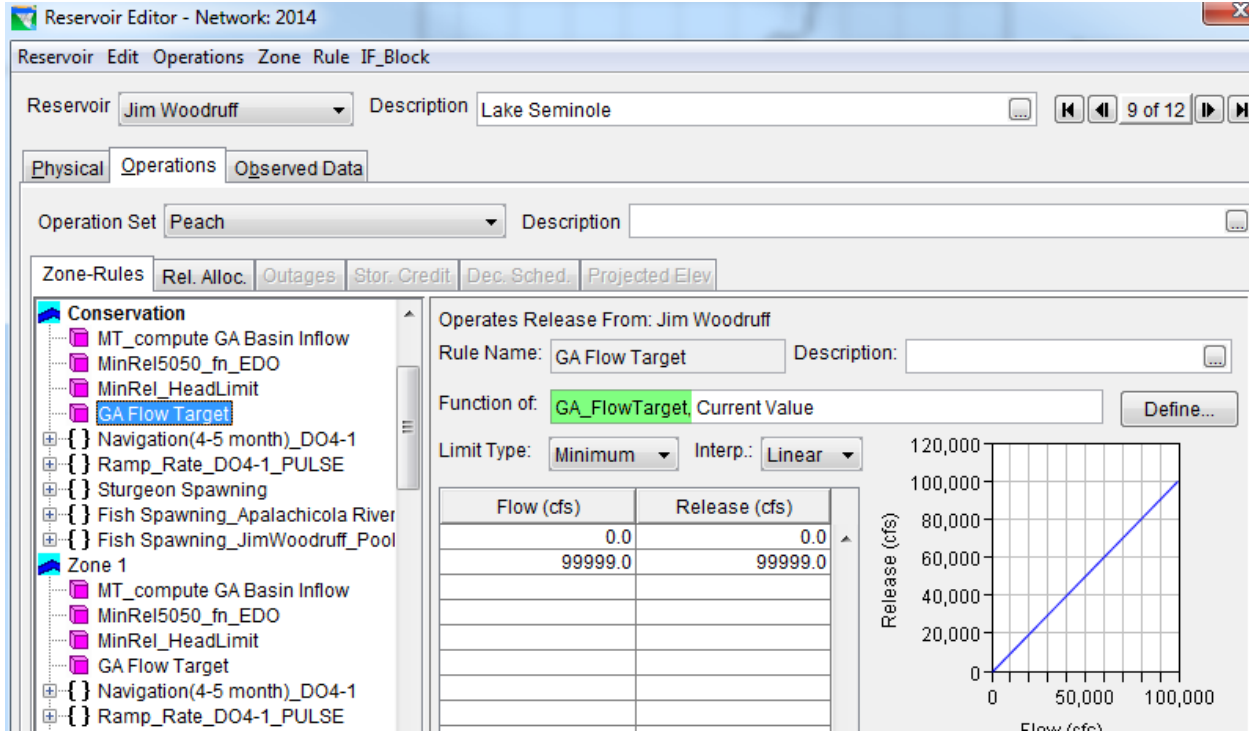


Figure H.13 Example of Applying State Variable “GA_FlowTarget”

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.

Appendix H – State Variables and Utility Scripts

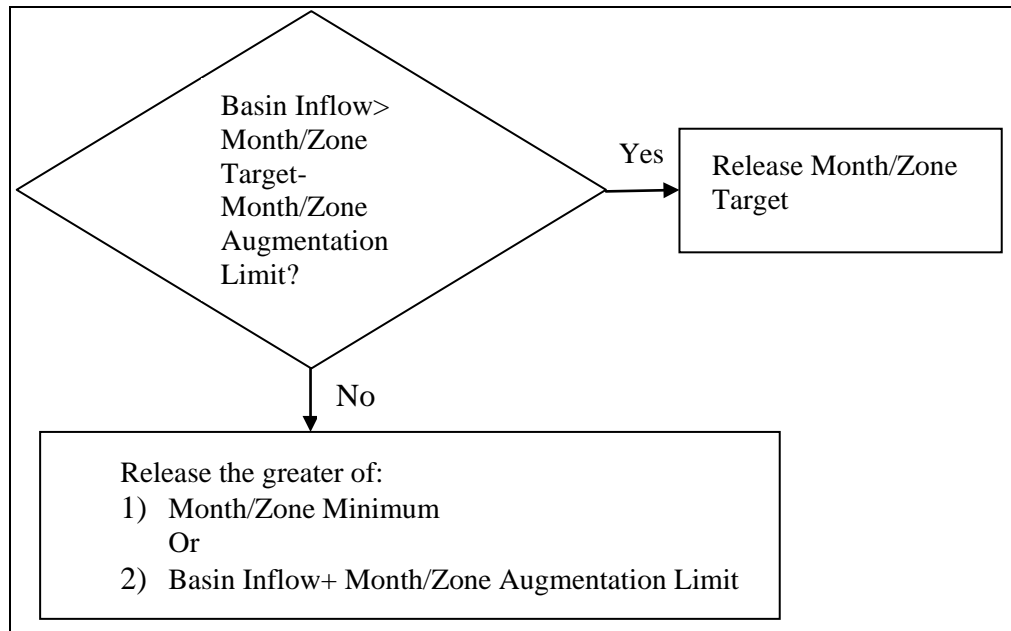


Figure H.14 Example of Applying State Variable FWS_FlowTarget

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.

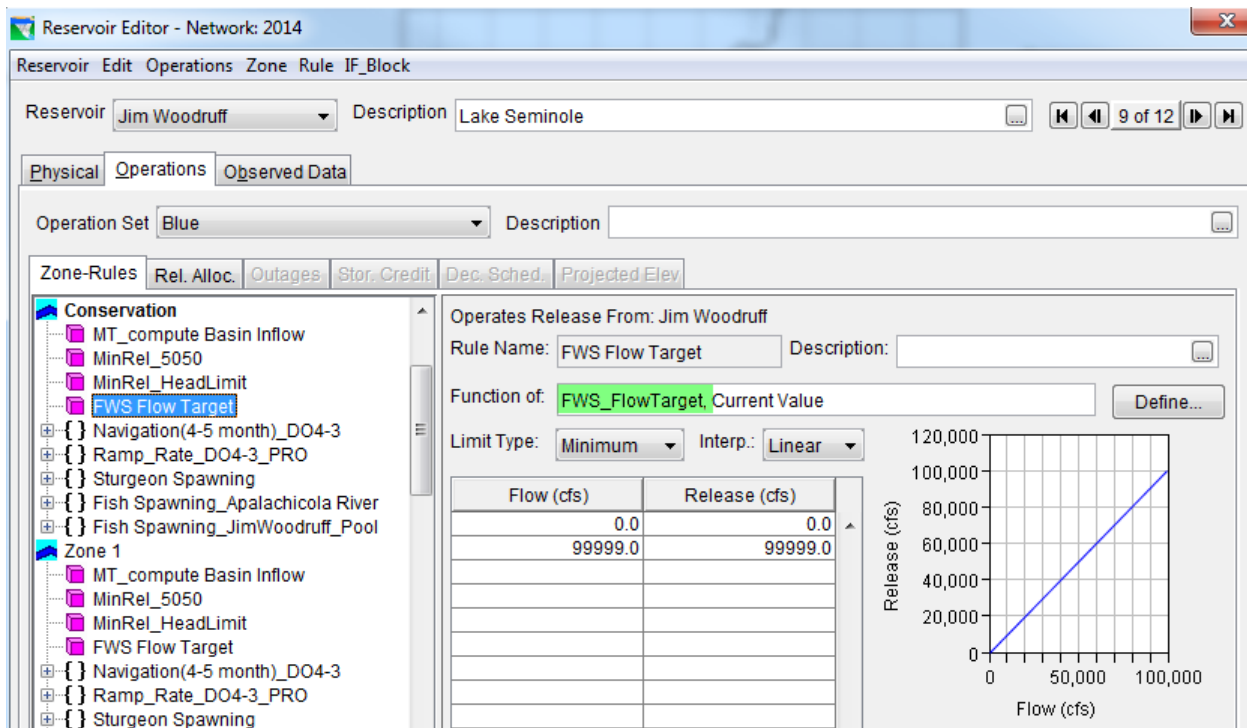


Figure H.15 Example of Applying State Variable “FWS_FlowTarget”

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.

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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).

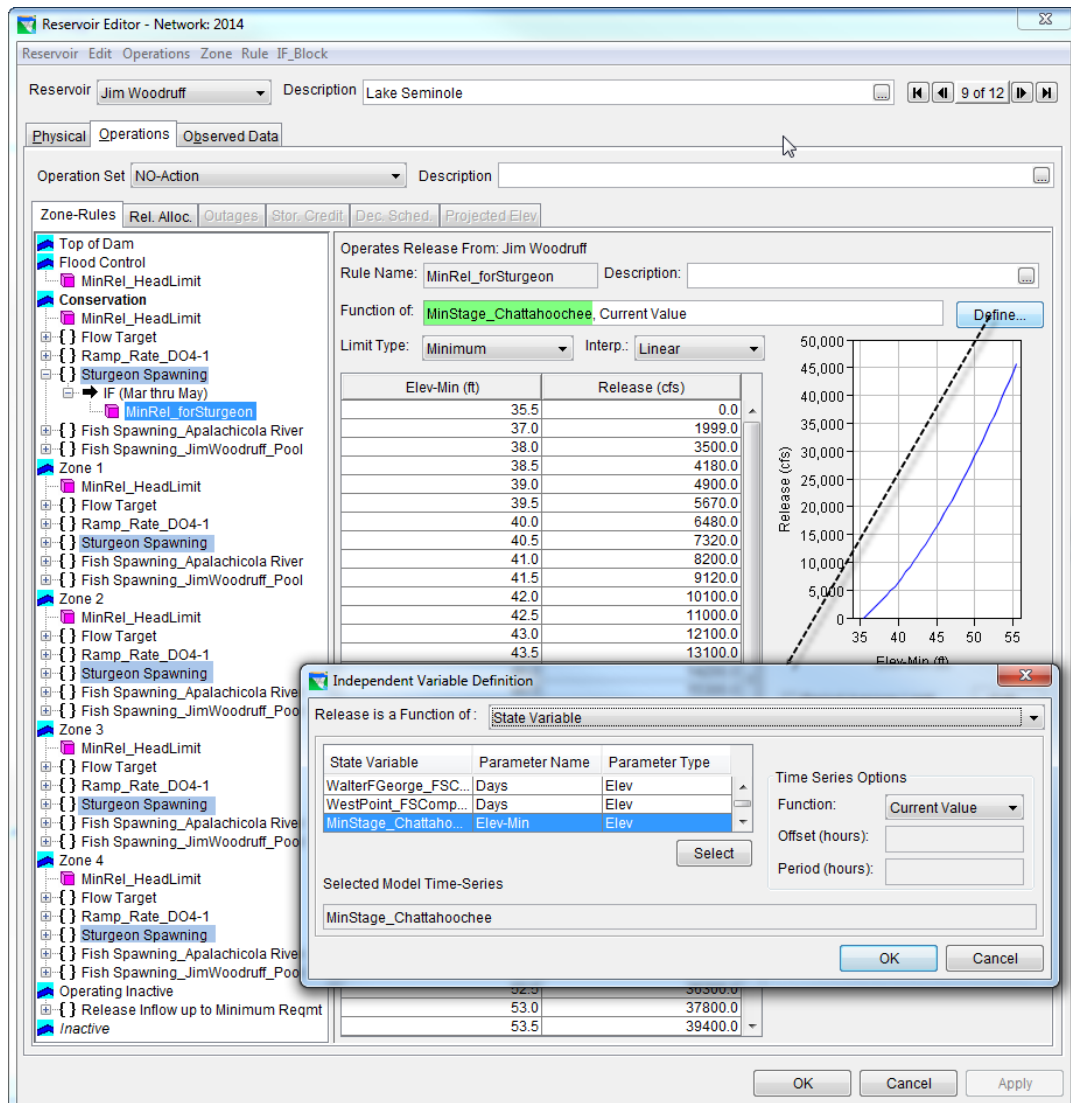


Figure H.16 Example of Applying State Variable “MinStage_Chattahoochee”

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 (see Table 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:

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```
5 # State variable: Buford_Elev_State
6 # Code=0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #   =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #   =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #   =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #   =7: The pool has dropped more than 0.50 ft from the base elevation
14
```

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:

```
42 LL_ELEV_TS = network.getTimeSeries("Reservoir","Buford","Pool","Elev")
43 LL_ELEV = LL_ELEV_TS.getPreviousValue(currentRuntimestep)
44 BaseELEV_StVar=network.getStateVariable("Buford_BaseElev")
45 BaseELEV_Pre=BaseELEV_StVar.getPreviousValue(currentRuntimestep)
46
47 if BaseELEV_Pre < LL_ELEV:
48     # Pool is rising, reset BaseELEV
49     BaseELEV_Cur=LL_ELEV
50     Code=0
51
52 else :
53     # Pool is steady or falling
54     BaseELEV_Cur=BaseELEV_Pre
55
56     Diff=BaseELEV_Pre - LL_ELEV
57     if Diff <=0.3:
58         Code=2
59     elif Diff >0.3 and Diff<=0.4:
60         Code=3
61     elif Diff >0.4 and Diff<=0.45:
62         Code=4
63     elif Diff >0.45 and Diff<=0.49:
64         Code=5
65     elif Diff >0.49 and Diff<=0.50:
66         Code=6
67     else:
68         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.17 shows how the Buford_Elev_State state variable is used to specify the maximum elevation rate of change limit rules.

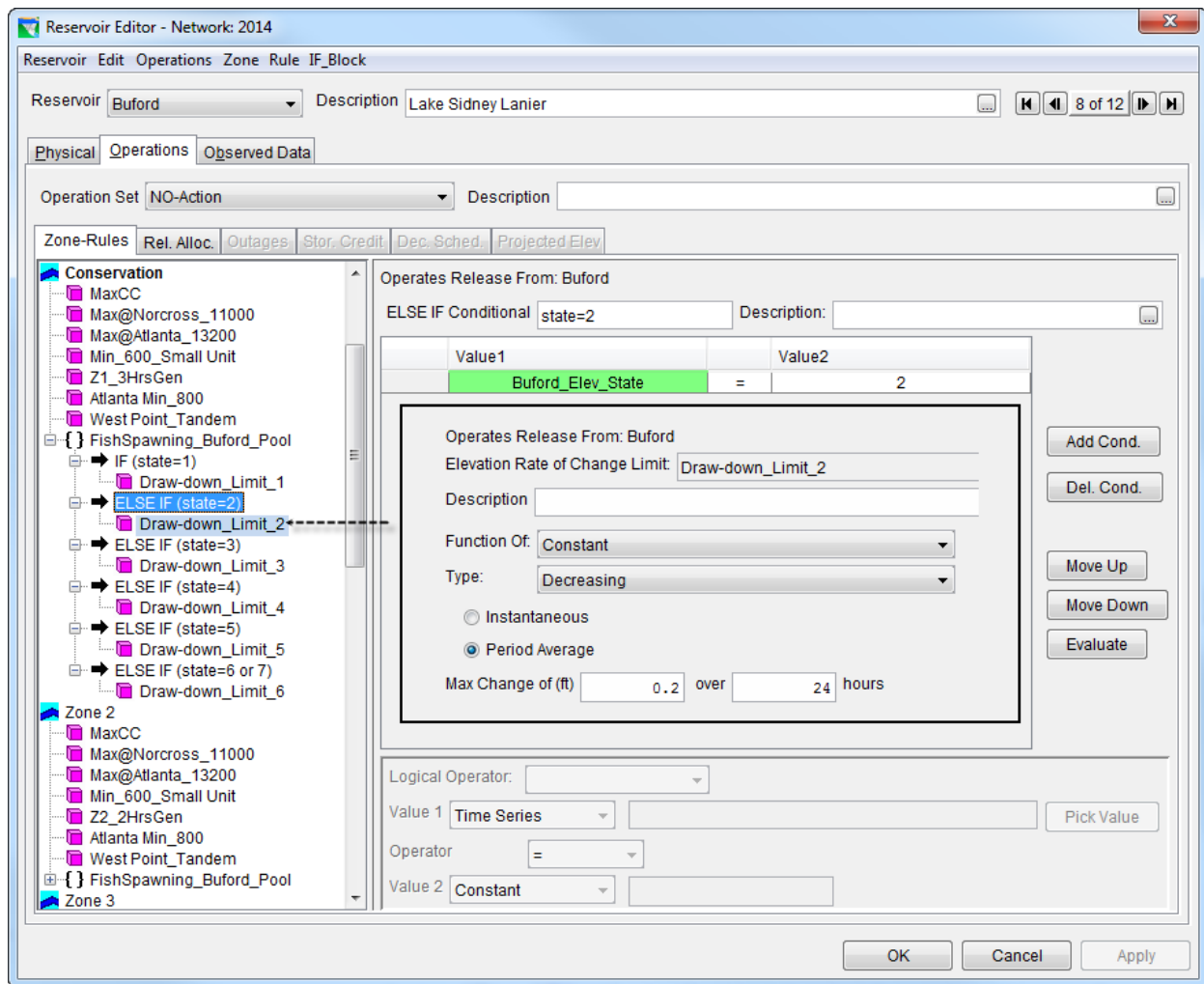


Figure H.17 Example of Applying State Variable “Buford_Elev_State”

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.

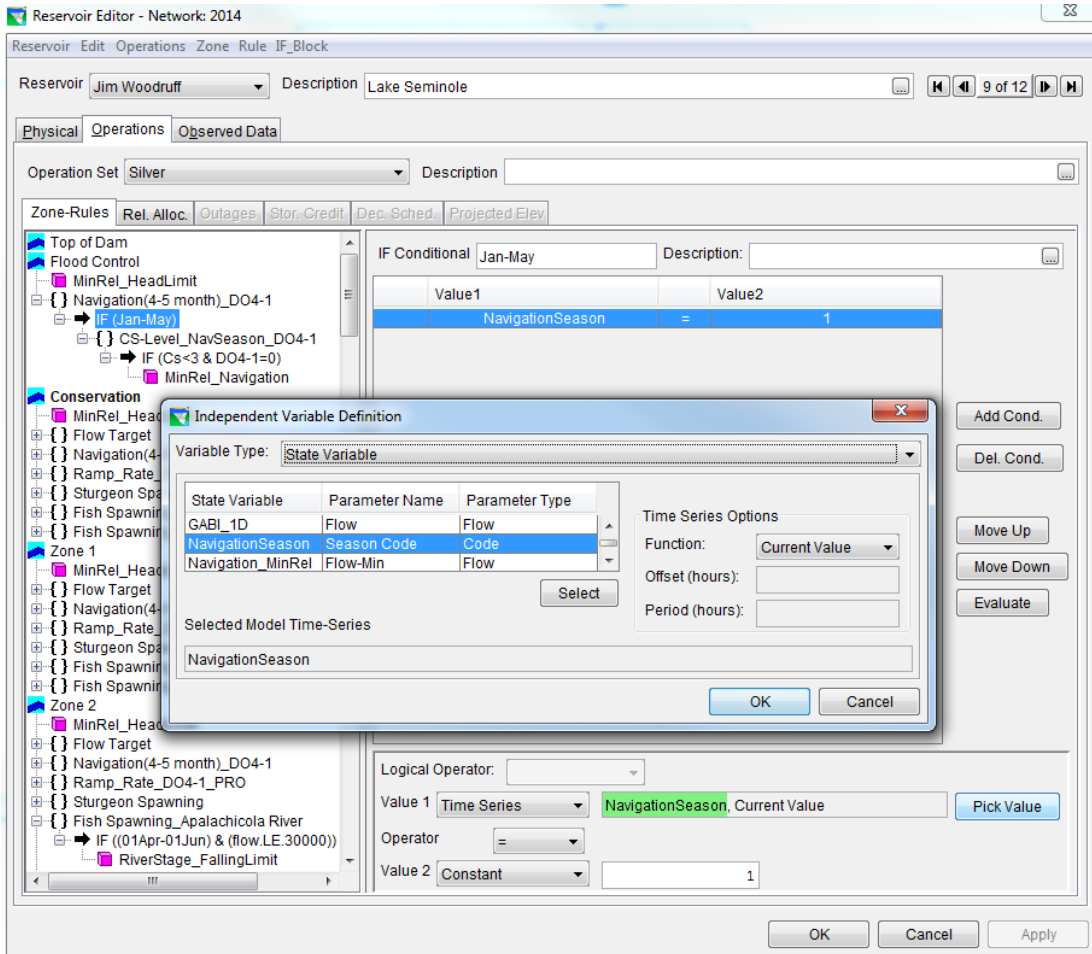


Figure H.18 Example of Applying State Variable “NavigationSeason”

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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.

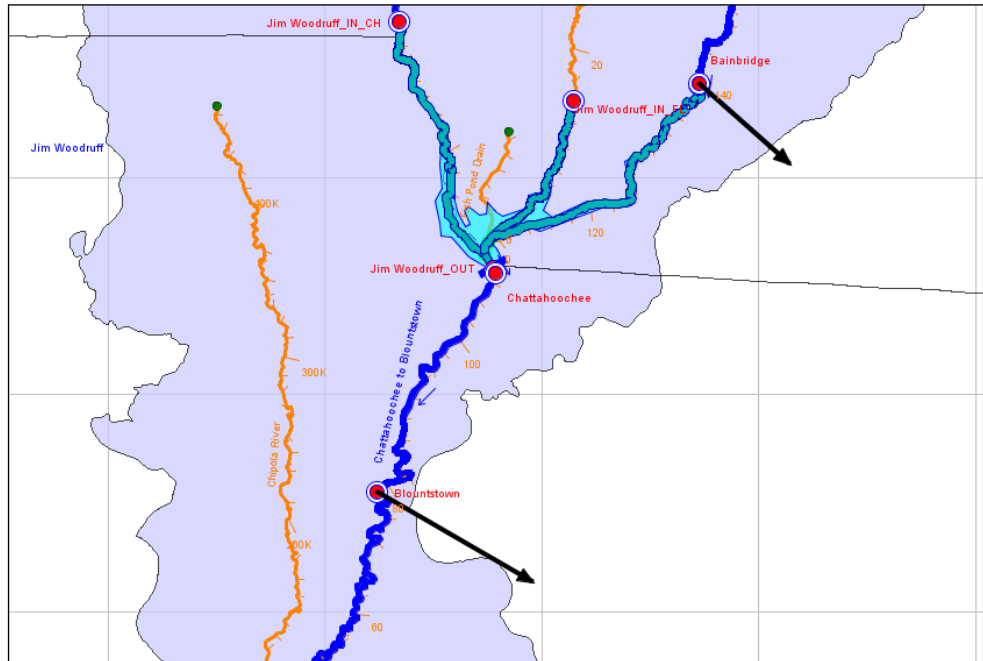


Figure H.19 Location of Blountstown Downstream of Jim Woodruff

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

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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 sum 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	$\geq 34,000$	=25,000
		$\geq \min(16,000; 9\text{ft NavQ}-9\text{ft Augmentation})$	= $\max(16,000+50\%BI > 16,000; 9\text{ft NavQ})$
		$\geq 8\text{ft NavQ}-8\text{ft Augmentation}$	=8ft NavQ
		$\geq 7\text{ft NavQ}-7\text{ft Augmentation}$	=7 ft NavQ
		$\geq 5,000$ and $< 7\text{ft NavQ}-7\text{ft Augmentation}$	=BI
		$< 5,000$	=5,000
	Zone 2	$\geq 34,000$	=25,000
		$\geq \min(16,000; 9\text{ft NavQ}-9\text{ft Augmentation})$	= $\max(16,000+50\%BI > 16,000; 9\text{ft NavQ}+50\%BI > 9\text{ft NavQ})$
		$\geq 8\text{ft NavQ}-8\text{ft Augmentation}$	=8ft NavQ
		$\geq 7\text{ft NavQ}-7\text{ft Augmentation}$	=7 ft NavQ
		$\geq 5,000$ and $< 7\text{ft NavQ}-7\text{ft Augmentation}$	=BI
		$< 5,000$	=5,000
	Zone 3	$\geq 39,000$	=25,000
		$\geq 9\text{ft NavQ}-9\text{ft Augmentation}$	= $9\text{ft NavQ}+50\%BI > 9\text{ft NavQ}$
		$\geq 8\text{ft NavQ}-8\text{ft Augmentation}$	=8ft NavQ
		$\geq 7\text{ft NavQ}-7\text{ft Augmentation}$	=7 ft NavQ
		$\geq 5,000$ and $< 7\text{ft NavQ}-7\text{ft Augmentation}$	=BI
		$< 5,000$	=5,000
Jun-Nov	Zones 1,2, and 3	$\geq 22,000$	= $\max(16,000; 9\text{ft NavQ})$
		$\geq 9\text{ft NavQ}-9\text{ft Augmentation}$	=9ft NavQ
		$\geq 8\text{ft NavQ}-8\text{ft Augmentation}$	=8 ft NavQ
		$\geq 7\text{ft NavQ}-7\text{ft Augmentation}$	=7 ft NavQ
		$\geq 10,000$ and $< 7\text{ft NavQ}-7\text{ft Augmentation}$	= $10,000 + 50\% BI > 10,000$
		$\geq 5,000$ and $< 10,000$	=BI
		$< 5,000$	=5,000
Dec-Feb	Zones 1,2, and 3	$\geq 9\text{ft NavQ}-9\text{ft Augmentation}$	=9ft NavQ
		$\geq 8\text{ft NavQ}-8\text{ft Augmentation}$	=8 ft NavQ
		$\geq 7\text{ft NavQ}-7\text{ft Augmentation}$	=7 ft NavQ
		$< 7\text{ft NavQ}-7\text{ft Augmentation}$	=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

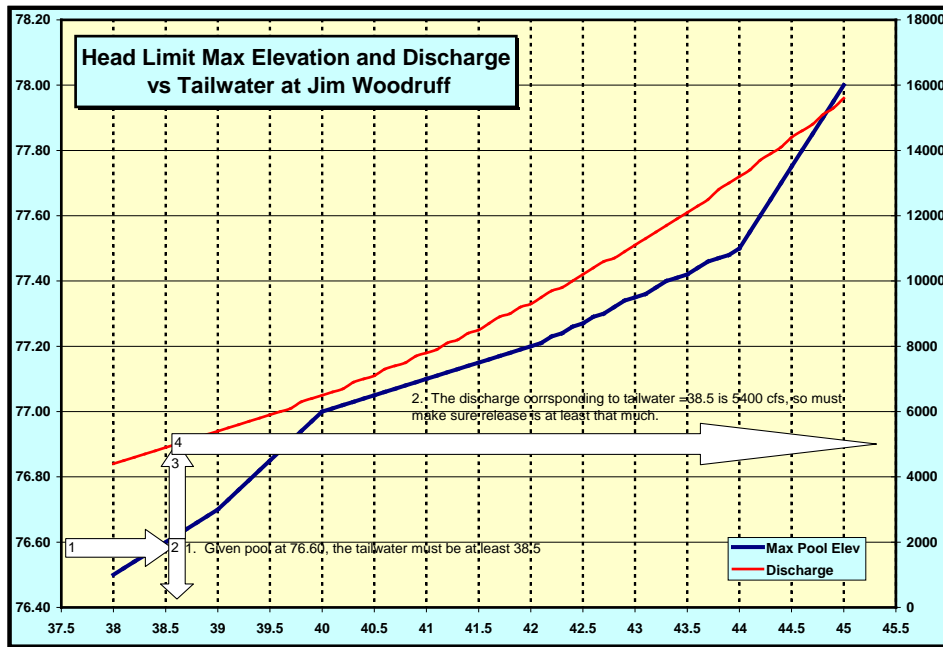
This state variable determines the minimum tailwater elevation needed at Jim Woodruff Dam based on the dam’s maximum head limit curve determined for dam structure stability. The curve was provided by SAM, in a spreadsheet, named “Headlimits_updatedForChattahooche.xls”.

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:

```

6 MaxPoolElev= [
7 [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,
8 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,
9 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,
10 77.50,77.55,77.60,77.65,77.70,77.75,77.80,77.85,77.90,77.95,78.00],
11 [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,
12 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,
13 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,
14 44., 44.1, 44.2, 44.3, 44.4, 44.5, 44.6, 44.7, 44.8, 44.9,45.]
15 ]
    
```

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.

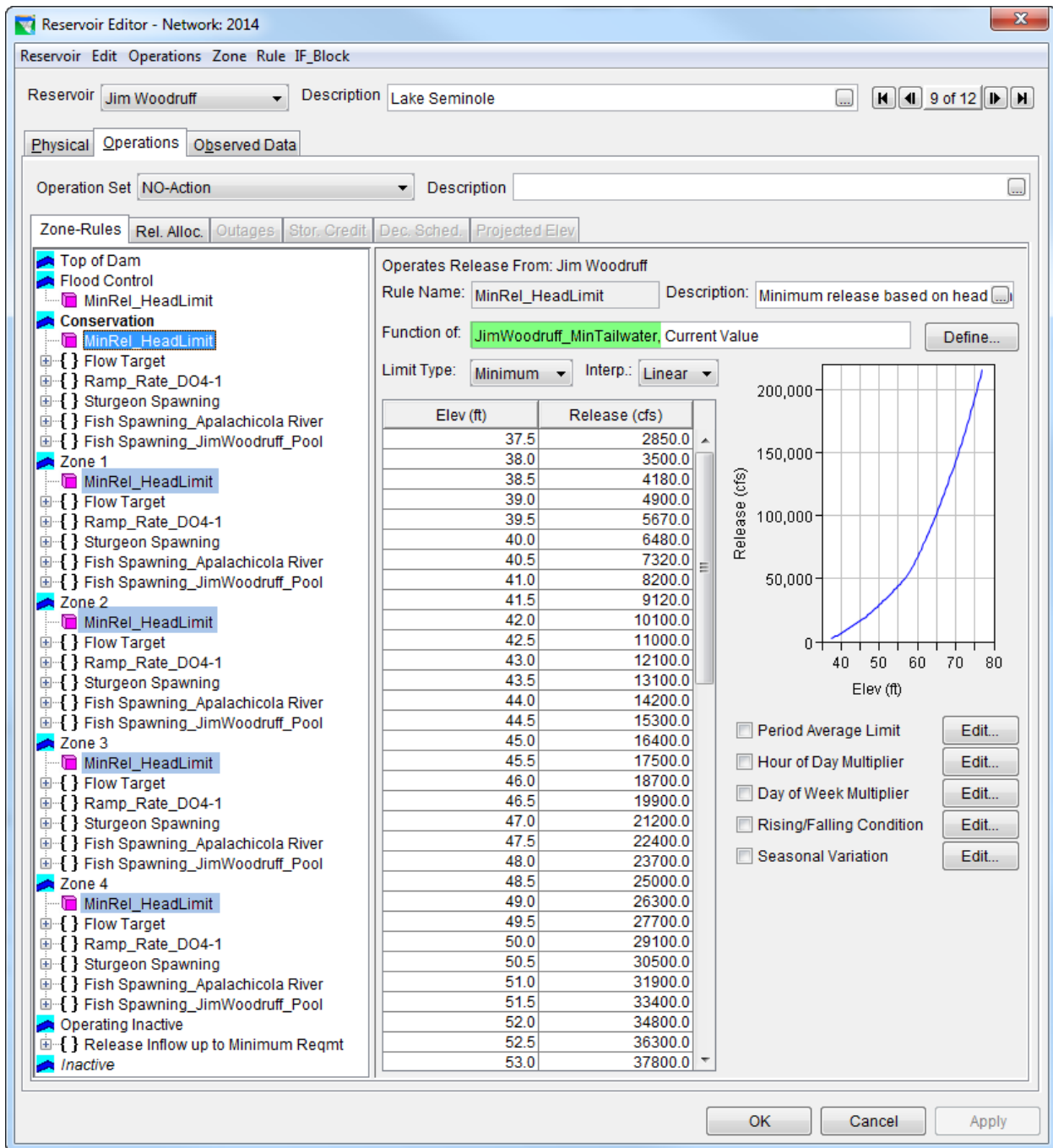


Figure H.20 Example of Applying State Variable “JimWoodruff_MinTailwater”

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).

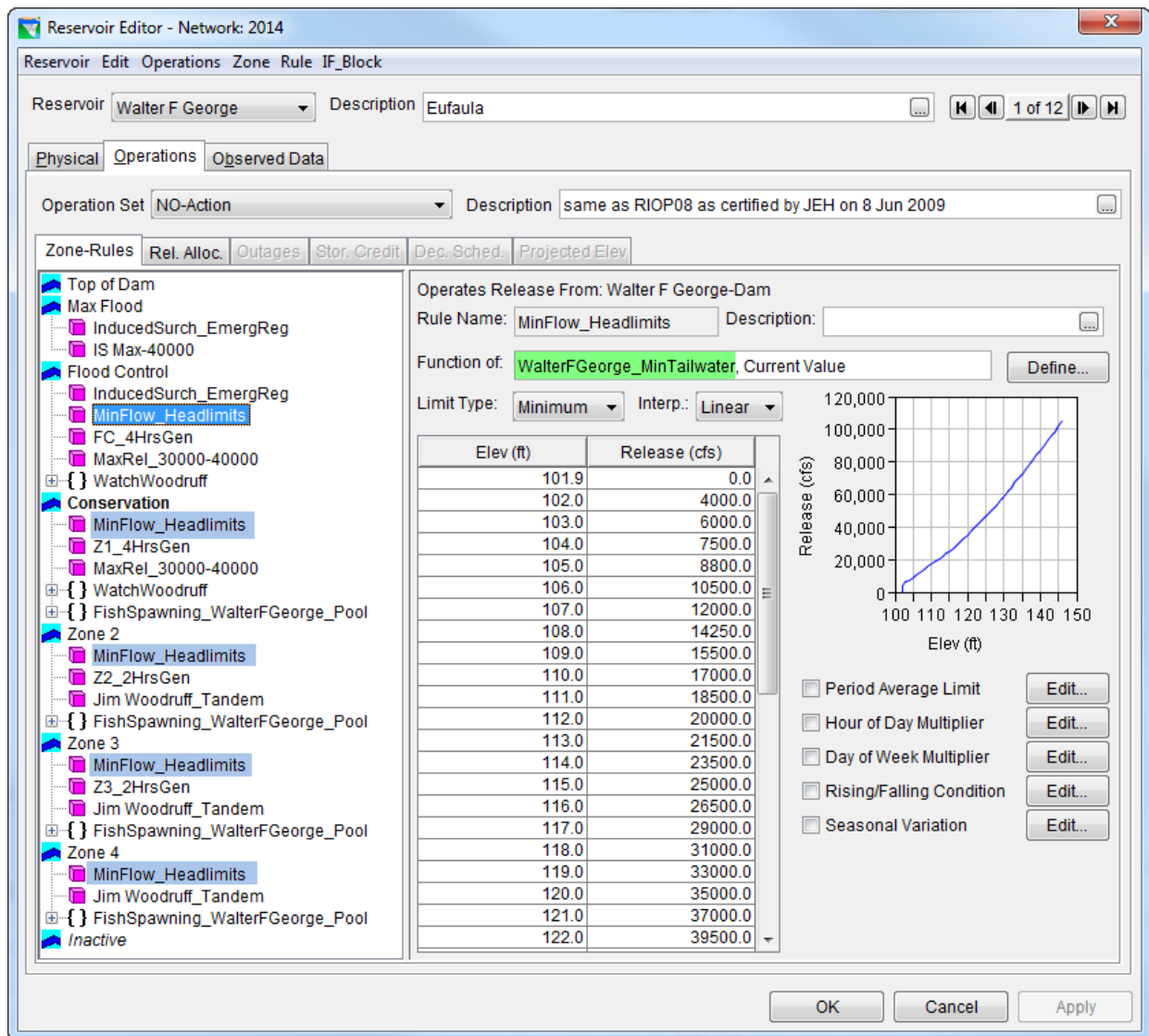


Figure H.21 Example of Applying State Variable “WalterFGeorge_MinTailwater”

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

The screenshot shows the 'State Variable Editor - Network: 2014' window. The 'Name' field is 'WestPoint_GCBuffer' and the 'Parameter Type' is 'Code'. The 'State Variable Type' is 'Jython Script'. The 'Main' tab is active, displaying the following Jython script:

```

1 # determine if the pool elevation at the end of the last timestep is within 0.05' of the guide curve.
2 # if so, state=1, else state=0.
3
4 elev = network.getTimeSeries("Reservoir","West Point", "Pool", "Elev").getPreviousValue(currentRuntimestep)
5 gc = network.getTimeSeries("Reservoir","West Point", "Conservation", "Elev-ZONE").getPreviousValue(currentRuntimestep)
6 gcnext =network.getTimeSeries("Reservoir","West Point", "Conservation", "Elev-ZONE").getCurrentValue(currentRuntimestep)
7
8 if gc < gcnext:
9     # rising limb of guide curve, the problem area
10    gcHigh = gcnext+0.05
11    gcLow = gc-0.05
12    if (elev >= gcLow and elev <= gcHigh):
13        state = 1
14    else:
15        state = 0
16 elif gc > gcnext:
17    # falling limb of guide curve
18    state = 0
19 else:
20    # flat spot in guide curve
21    gcHigh = gc+0.05
22    gcLow = gc-0.05
23    if (elev >= gcLow and elev <= gcHigh):
24        state = 1
25    else:
26        state = 0
27
28 currentVariable.setValue(currentRuntimestep, state)

```

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).

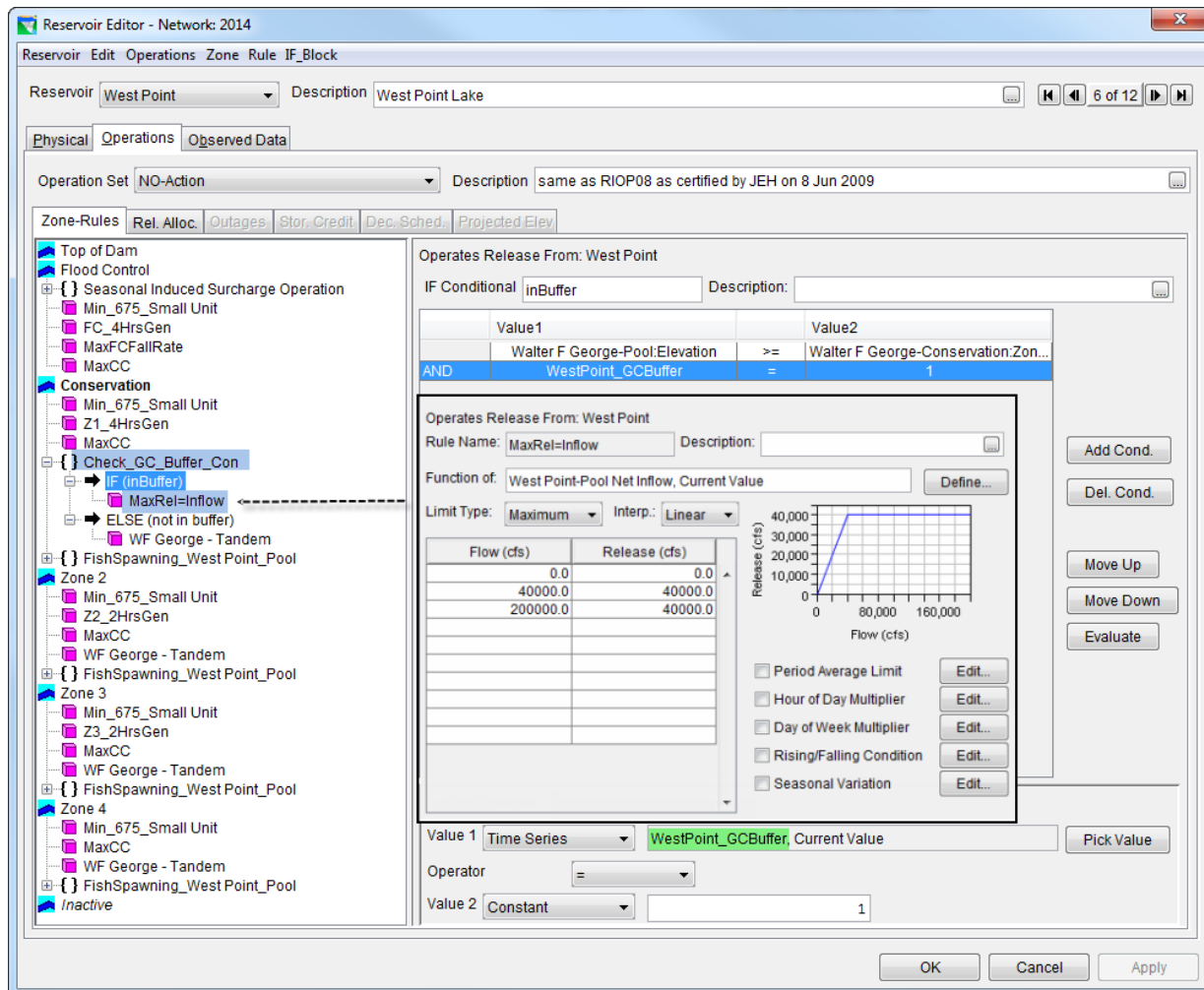


Figure H.23 Example of Applying State Variable “WestPoint_GCBuffer” and Model Variable “West Point-Pool Net Inflow”

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 in Figure H.24, the state variable script defines April 15 through November 19 as summer and the rest of a year as winter.

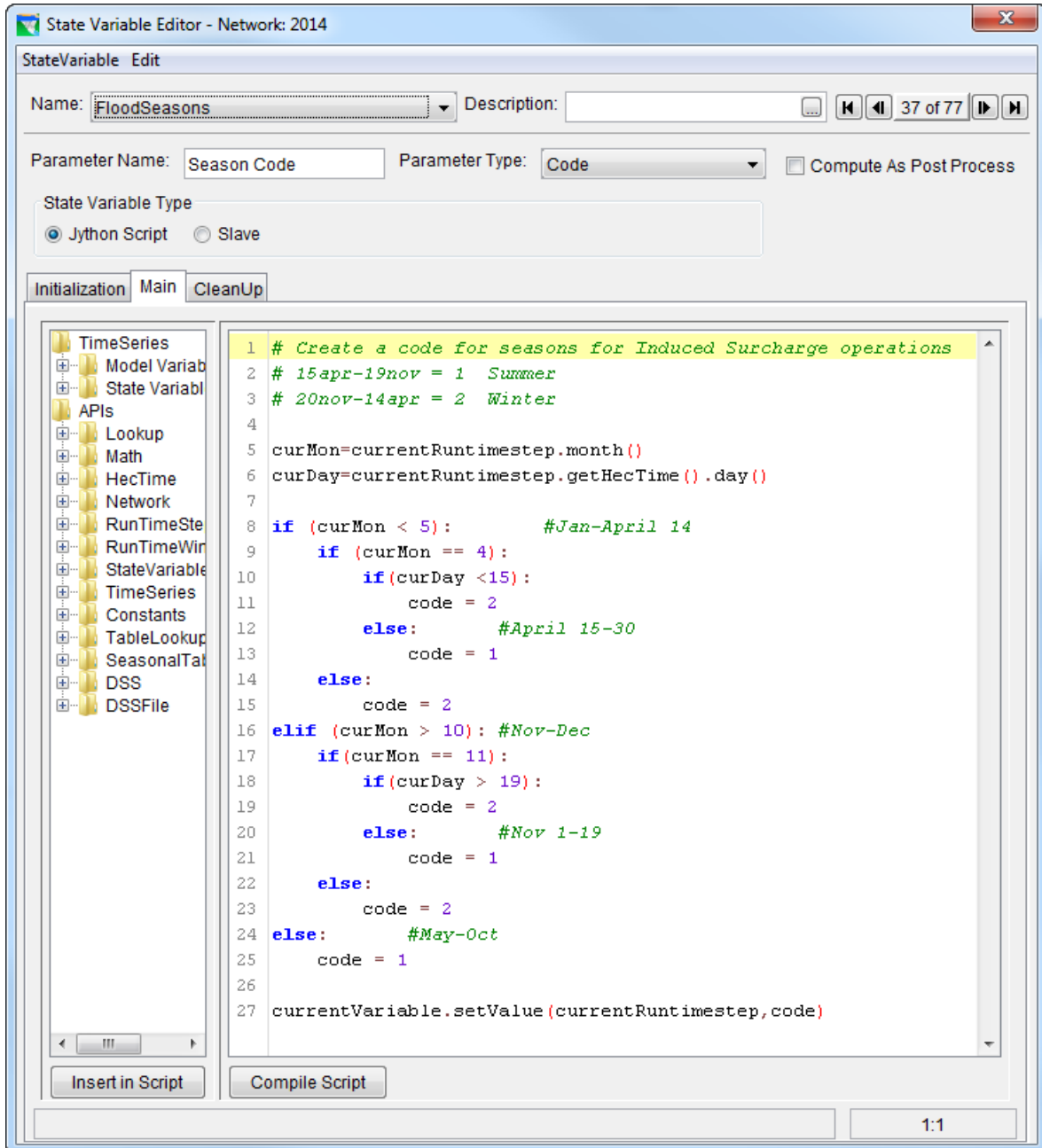


Figure H.24 Main Script for the State Variable “FloodSeasons”

Depending on the value of the “FloodSeasons” state variable, different induced surcharge operation rules are applied as shown in Figure H.25.

Appendix H – State Variables and Utility Scripts

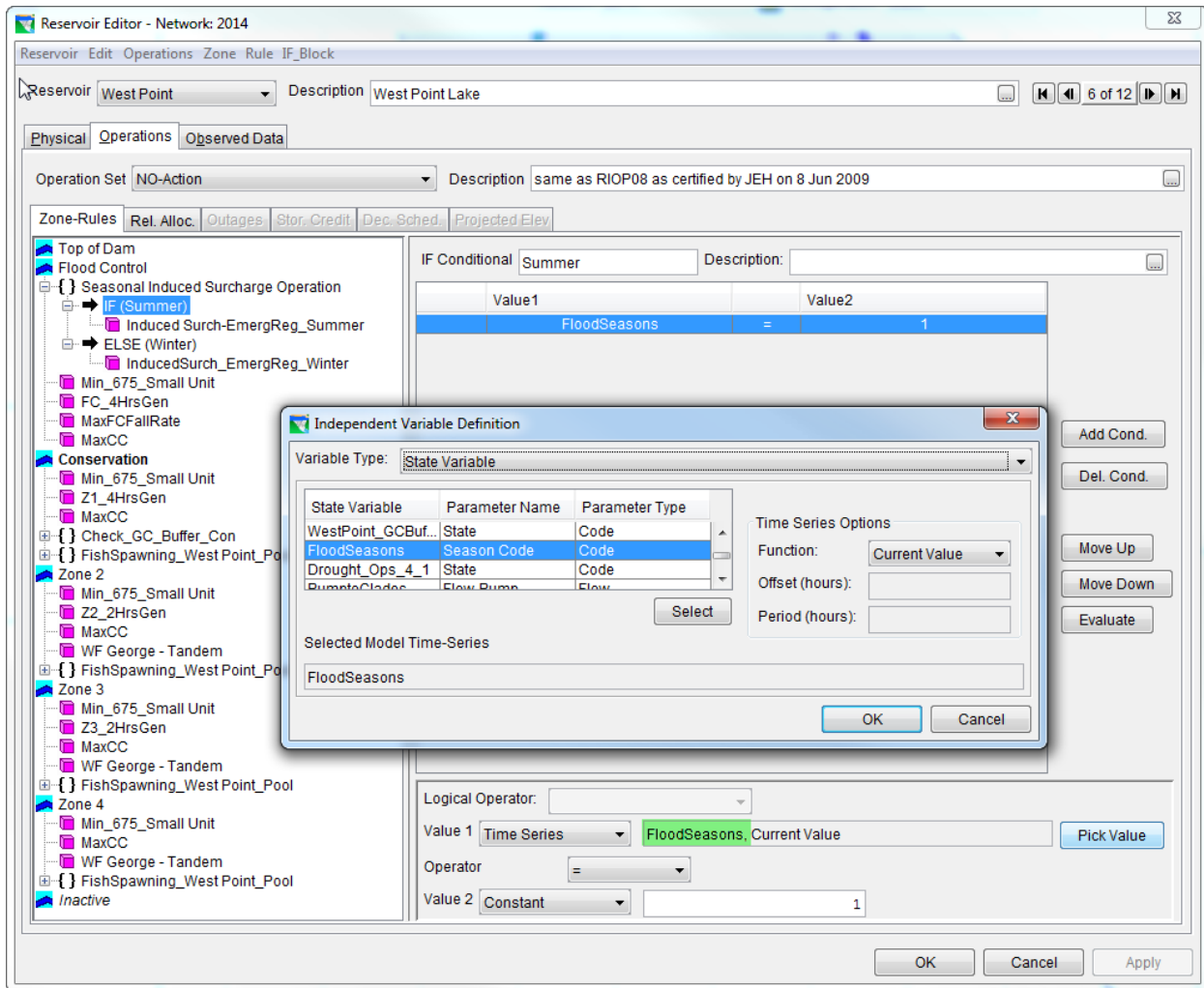


Figure H.25 Using the State Variable “FloodSeasons” at West Point

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

Appendix H – State Variables and Utility Scripts

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)
```

Appendix H – State Variables and Utility Scripts

```
# ----- # 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()
#
```

Appendix H – State Variables and Utility Scripts

```
# -----  
  
# 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)
```

Appendix H – State Variables and Utility Scripts

```

# 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

```

Appendix H – State Variables and Utility Scripts

```
        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 occurred 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" + 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()
```

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```
#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
```

Appendix H – State Variables and Utility Scripts

```
    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)
```


Appendix H – State Variables and Utility Scripts

```
currentVariable.setValue(currentRunimestep, 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 state 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" + currentRuntimeStep.dateTimeString() + "\tCompositeStorage " + `CS_state`
#network.printLogMessage(message)

DOops_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)
```

Appendix H – State Variables and Utility Scripts

```

#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:

```

Appendix H – State Variables and Utility Scripts

```
# 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)
```

Appendix H – State Variables and Utility Scripts

```
#####  
##### 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...
```

Appendix H – State Variables and Utility Scripts

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 state 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)

DOops_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`
```

Appendix H – State Variables and Utility Scripts

```

#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

```

Appendix H – State Variables and Utility Scripts

```
        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)
```


Appendix H – State Variables and Utility Scripts

```
#####  
##### 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
# situation. 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
#
```

Appendix H – State Variables and Utility Scripts

```
# 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 Appalaciicola 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 variable 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 revised 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
```

Appendix H – State Variables and Utility Scripts

#####

```
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)
```

Appendix H – State Variables and Utility Scripts

```
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
```


Appendix H – State Variables and Utility Scripts

#####

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()

Appendix H – State Variables and Utility Scripts

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
```

Appendix H – State Variables and Utility Scripts

```
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...
```

Appendix H – State Variables and Utility Scripts

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)
```

Appendix H – State Variables and Utility Scripts

```
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...
```

Appendix H – State Variables and Utility Scripts

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 upcoming 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]
UP80365=[13743, 13711, 14220, 14571, 14888, 15420, 15125, 15286, 15364, 15689, 16093,
15782, 15345, 14964, 14590, 14556, 14460, 14365, 14979, 15309, 15443, 15609, 15500,
```

Appendix H – State Variables and Utility Scripts

15291,	14931,	14386,	13783,	13275,	13350,	13411,	13617,	13860,	13869,	14140,	14386,
14543,	14903,	14954,	14966,	15370,	17566,	19706,	19752,	19354,	18993,	18766,	18896,
19159,	19134,	19054,	19091,	19129,	19123,	19051,	19080,	19043,	19080,	20837,	20720,
20714,	22717,	23965,	23613,	23742,	23996,	23949,	23840,	23609,	22857,	22315,	22114,
22166,	22543,	23503,	24637,	23986,	24231,	23860,	23271,	22517,	22377,	22409,	22120,
21520,	20997,	21071,	20842,	20851,	20607,	20783,	21146,	20803,	20551,	21097,	21754,
21269,	20787,	20624,	20326,	20511,	19963,	19634,	19169,	18914,	18523,	18857,	18983,
18760,	18457,	17994,	17577,	18429,	17846,	17520,	17723,	17769,	17757,	17597,	17234,
16914,	16729,	16400,	16246,	15983,	15540,	15143,	15023,	14931,	14671,	14691,	14834,
14651,	14354,	14114,	14145,	13477,	13265,	13449,	14014,	13743,	13494,	13323,	13100,
12809,	12503,	12163,	12097,	11871,	11538,	11162,	10535,	10013,	9803,	9675,	9584,
9612,	9775,	9923,	9970,	10035,	10107,	10094,	10085,	10223,	10445,	10565,	10918,
11665,	12380,	12169,	11797,	11643,	11509,	11349,	11200,	11051,	11020,	10839,	10720,
10911,	11194,	10903,	10356,	10150,	9882,	9978,	10075,	9868,	9937,	11119,	11150,
11267,	11773,	12203,	12366,	12251,	11928,	11989,	11960,	11824,	11520,	11407,	11309,
11411,	11507,	11825,	12585,	12640,	12763,	12407,	12203,	12220,	11910,	11877,	11748,
11554,	11334,	11023,	11006,	11183,	10897,	10851,	10836,	11269,	11363,	11362,	11187,
11092,	11229,	10928,	10716,	10574,	10471,	10305,	10156,	9977,	10165,	9836,	9649,
9423,	9326,	9247,	9107,	8985,	8809,	8608,	8349,	8100,	7971,	8325,	8429,
8259,	8142,	8179,	8230,	8185,	8150,	8187,	8234,	8297,	8343,	8422,	8357,
8364,	8319,	8507,	8330,	8177,	7994,	7871,	7754,	7683,	7678,	7569,	7508,
7481,	7452,	7420,	7295,	7317,	7238,	7238,	7249,	7263,	7239,	7191,	7144,
7107,	7068,	7080,	7109,	7128,	7131,	7095,	7006,	6966,	6943,	6909,	6860,
6836,	7067,	7141,	7120,	7120,	7140,	7149,	7103,	7012,	6996,	6991,	6981,
6985,	7025,	7218,	7593,	7613,	7613,	7626,	7738,	7839,	7945,	8095,	8235,
8448,	8595,	8653,	8652,	8651,	8501,	8348,	8264,	8440,	8729,	9011,	9075,
9103,	9181,	9474,	9508,	9454,	9330,	9469,	9490,	9600,	10064,	10251,	10355,
10318,	10265,	10248,	10299,	10643,	10720,	10837,	10989,	11246,	11429,	11503,	11903,
12283,	12540,	12997,	13697,	13722,	13849]						
UP85365=[12571,	13193,	13488,	13980,	14066,	14017,	14263,	14454,	14821,	14514,	14183,	
14157,	14269,	14229,	14134,	13955,	13525,	13473,	13485,	13413,	13242,	13084,	13009,
12937,	12874,	12844,	12890,	13029,	12686,	12817,	13392,	13394,	13401,	13794,	13949,
14086,	14134,	14020,	13923,	14034,	14377,	14806,	15146,	15614,	16001,	17225,	18399,
18620,	18286,	17626,	16829,	16111,	15431,	15057,	15234,	15771,	17329,	17346,	17640,
19246,	20251,	22959,	22516,	22114,	21509,	20920,	20606,	20543,	20483,	20989,	21104,
21145,	21823,	21920,	22203,	22837,	22083,	21631,	22149,	21913,	21446,	21123,	21029,
20635,	20546,	20300,	20234,	20028,	19595,	19821,	19457,	19338,	19589,	19764,	19793,
19833,	19143,	18669,	18289,	19224,	18963,	18801,	18510,	18149,	17869,	17580,	17289,
16977,	16686,	16421,	16920,	16963,	17177,	16443,	16043,	16060,	16106,	16143,	16303,
16466,	16274,	15894,	15191,	14926,	14763,	14577,	14043,	13583,	13194,	12937,	12763,
12749,	12697,	12957,	13217,	12910,	12523,	13079,	13221,	13148,	13058,	12726,	12416,
12049,	11768,	11731,	11471,	11154,	10770,	10479,	10249,	9869,	9703,	9510,	9366,
9275,	9476,	9467,	9426,	9326,	9332,	9353,	9382,	9341,	9711,	10082,	9906,
9613,	9511,	9461,	9482,	9587,	9625,	9693,	9768,	9848,	9797,	9589,	9429,
9274,	9389,	9843,	10254,	9838,	9620,	9455,	9379,	9364,	9789,	10187,	10625,
10752,	10511,	10258,	10556,	11128,	11503,	11315,	10994,	10830,	11270,	11277,	11110,
10986,	11169,	11292,	11334,	11268,	11229,	11039,	10350,	9842,	9511,	9318,	9083,
9107,	9645,	9677,	9484,	9589,	9800,	9957,	10748,	10225,	9809,	9454,	10151,
10913,	10849,	10702,	10486,	10234,	10023,	9798,	9534,	9558,	9642,	9500,	9371,
9232,	8932,	8587,	8327,	8151,	8028,	7931,	7833,	7854,	7809,	7625,	7443,
7342,	7335,	7311,	7354,	7307,	7214,	7098,	6975,	6877,	6837,	6799,	6760,
7102,	7806,	7593,	7471,	7346,	7221,	7109,	6956,	6942,	6906,	6783,	6668,
6671,	6683,	6940,	7211,	6935,	6974,	7099,	7075,	7046,	6995,	6907,	6812,
6970,	7034,	6987,	6960,	6963,	6939,	6917,	6882,	6800,	6654,	6543,	6507,
6592,	6666,	6641,	6636,	6627,	6626,	6600,	6598,	6569,	6557,	6567,	6586,
6715,	6896,	7047,	7074,	7054,	7100,	7173,	7179,	7188,	7384,	7609,	7796,
7737,	7692,	7669,	7669,	7669,	7693,	7833,	8024,	8064,	8400,	8463,	8593,
8823,	9124,	9286,	9403,	9295,	9265,	9248,	9367,	9504,	9593,	9691,	9649,
9657,	9618,	9704,	9851,	9967,	10125,	10337,	10656,	10861,	10713,	10658,	10887,
11543,	11600,	12166,	12903,	13086,	12763]						
UP90365=[9497,	9527,	9564,	9624,	9698,	10504,	11727,	11587,	11216,	11174,	11383,	
11601,	11709,	11741,	11944,	11780,	11657,	11626,	11721,	11999,	12421,	13444,	13679,
13751,	13793,	13750,	13602,	13080,	12694,	13404,	14003,	14411,	14563,	14557,	15656,
16861,	17417,	18248,	19194,	18786,	19183,	18584,	17930,	16754,	16854,	17274,	17597,
17697,	18191,	17342,	16214,	14955,	14957,	15021,	15387,	16024,	20151,	19886,	18859,
17875,	17037,	17042,	17390,	17674,	17519,	17154,	16339,	15300,	14449,	13833,	13606,
13238,	13186,	13023,	13299,	13571,	13805,	14500,	15459,	16505,	17298,	16693,	15791,
15149,	15541,	15624,	15328,	15030,	14848,	15710,	15457,	15119,	14880,	14362,	14189,
14261,	14457,	13353,	12691,	12643,	13142,	13476,	13243,	13172,	13131,	12986,	12751,
12615,	12353,	11815,	11216,	11076,	11222,	11199,	11066,	10894,	10470,	10191,	10469,
10568,	10309,	9956,	9535,	9821,	10262,	10015,	10261,	10149,	9869,	9515,	9595,
9312,	9041,	8857,	8884,	8860,	8867,	8868,	8828,	8584,	8096,	7664,	7320,
7189,	7131,	7040,	7027,	7026,	6980,	6927,	6834,	6972,	7178,	7062,	6905,

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6723,	6576,	6499,	6365,	6271,	6195,	6126,	6129,	6180,	6211,	6227,	6231,
6475,	6594,	6657,	6598,	6461,	6504,	6660,	6522,	6387,	6273,	6189,	6119,
6047,	6004,	5951,	5920,	5899,	5892,	5894,	5914,	5920,	5949,	5977,	6004,
6025,	6082,	6089,	6069,	6052,	6014,	5930,	5954,	6067,	6202,	6325,	6396,
6435,	6437,	6280,	6051,	5866,	5627,	5556,	5446,	5385,	5356,	5367,	5455,
5500,	5586,	5545,	5540,	5508,	5453,	5392,	5320,	5242,	5258,	5318,	5352,
5386,	5428,	5417,	5420,	5438,	5470,	5496,	5511,	5519,	5524,	5537,	5556,
5568,	5573,	5726,	5855,	6059,	6120,	6146,	6184,	6148,	6198,	6350,	6493,
6509,	6455,	6392,	6425,	6669,	6690,	6752,	6804,	6730,	6599,	6461,	6320,
6163,	6195,	6207,	6254,	6197,	6151,	6201,	6088,	6029,	5961,	5882,	5811,
5754,	5871,	6127,	6102,	6019,	5842,	5763,	5727,	5676,	5641,	5616,	5685,
5759,	5854,	5947,	5980,	5949,	5936,	5978,	6014,	6051,	6073,	6060,	6000,
5897,	5833,	5773,	5788,	5801,	5820,	5832,	5825,	5830,	5993,	6093,	6056,
5926,	5724,	5714,	5704,	5690,	5668,	5653,	5834,	6195,	6344,	6439,	6499,
6558,	6641,	6742,	6744,	6984,	7047,	7030,	7240,	7409,	7468,	7444,	7409,
7377,	7091,	7187,	7211,	7175,	7470,	7509,	7421,	7153,	7176,	7193,	7196,
7183,	7145,	7191,	7311,	7344,	7671,	8289,	8592,	8849,	9088,	9113,	9130,
9136,	9276,	9458,	9450,	9453,	9450]						
UP95365=[8121,	8178,	8272,	8366,	8761,	8771,	8674,	8612,	8647,	8829,	9086,	
9562,	10013,	10391,	10485,	10447,	10286,	10347,	10514,	10784,	11439,	11280,	11135,
11019,	11001,	11093,	11307,	11516,	11752,	11625,	11692,	11862,	12108,	12586,	12231,
11724,	12793,	15318,	15201,	15007,	13915,	13426,	13556,	13885,	13074,	12018,	10996,
10330,	10618,	11231,	11855,	12473,	11656,	10823,	10605,	10819,	11132,	11580,	12130,
13195,	14303,	15344,	16103,	16590,	16521,	16191,	15605,	14757,	14109,	13679,	13201,
13032,	12770,	12795,	12979,	13341,	13424,	13151,	13008,	13042,	13150,	13155,	13060,
13365,	12950,	12689,	12449,	12371,	12727,	13315,	13602,	13908,	13549,	13460,	12867,
12169,	11850,	11758,	11270,	11037,	11493,	11446,	11442,	11489,	11503,	11478,	11531,
12030,	11984,	11017,	10426,	9980,	9691,	9463,	9307,	9209,	9129,	8951,	8558,
8266,	8157,	8253,	8724,	8720,	8852,	8555,	7892,	7757,	7948,	8369,	8268,
8044,	7849,	7993,	8009,	7784,	7568,	7406,	7260,	7088,	6894,	6745,	6599,
6342,	6141,	6003,	5853,	5661,	5509,	5408,	5319,	5251,	5183,	5149,	5153,
5157,	5151,	5159,	5194,	5188,	5188,	5214,	5288,	5359,	5420,	5450,	5523,
5595,	5593,	5542,	5480,	5410,	5359,	5315,	5281,	5283,	5295,	5324,	5365,
5376,	5370,	5355,	5328,	5303,	5328,	5341,	5373,	5412,	5427,	5489,	5660,
5800,	5828,	5850,	5864,	5858,	5839,	5792,	5739,	5636,	5509,	5397,	5348,
5347,	5366,	5376,	5405,	5427,	5452,	5346,	5347,	5191,	5140,	5165,	5135,
5142,	5145,	5143,	5156,	5153,	5141,	5139,	5144,	5146,	5176,	5194,	5221,
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,

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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_It6k")
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")

```

Appendix H – State Variables and Utility Scripts

```
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
#-----
```

Appendix H – State Variables and Utility Scripts

```

FLBI7D = network.getStateVariable("FLBI_FMA7").getValue(currentRun timestep)
BI7D = network.getStateVariable("BI_FMA7").getValue(currentRun timestep)

if (BI7D > 10000):
    BI7Dgt10k = 1
else:
    BI7Dgt10k = 0

# Store for anlysis/QC purposes
BI7Dgt10kVar=currentVariable.localTimeSeriesGet("BI7Dgt10k")
BI7Dgt10kVar.setCurrentValue(currentRun timestep, BI7Dgt10k)
# -----
# CALCULATE 60-day average
# -----

Chatt_state_TS = network.getTimeSeries("Reservoir","Jim Woodruff", "Pool", "Flow-OUT")
Chatt_state_60 = Chatt_state_TS.getPeriodAverage(currentRun timestep, 60, 1)

# Store for anlysis/QC purposes
Chatt60Var=currentVariable.localTimeSeriesGet("FL_Chatt60")
Chatt60Var.setCurrentValue(currentRun timestep, 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(currentRun timestep, 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(currentRun timestep, 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) :
```

Appendix H – State Variables and Utility Scripts

```

                                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 analysis/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 compute 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()
```

Appendix H – State Variables and Utility Scripts

```

# 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)

```

Appendix H – State Variables and Utility Scripts

```

# 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

```

Appendix H – State Variables and Utility Scripts

```
        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 analysis/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, 2000, 0, 0,
#     0, 0]
#     Augmentation_Z2=[0, 2000, 2000, 2000, 4000, 2000, 2000, 2000, 2000, 1500, 1500,
#     1500, 1500]
#     Augmentation_Z3=[1000, 2000, 3000, 3000, 2000, 1000, 1000, 1000, 1000, 1000, 1000,
#     1000, 1000]
#     Augmentation_Z4=[0, 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)
```

Appendix H – State Variables and Utility Scripts

```

# ----- # 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()

#-----

```

Appendix H – State Variables and Utility Scripts

```
# 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")
```

Appendix H – State Variables and Utility Scripts

```
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--
```

Appendix H – State Variables and Utility Scripts

```
# _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
```

Appendix H – State Variables and Utility Scripts

#####

```
# 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")
```


Appendix H – State Variables and Utility Scripts

```
# 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 :
    BufordRule = BufordZ5Rule           # Below Zone 4

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
```

Appendix H – State Variables and Utility Scripts

```
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

Appendix H – State Variables and Utility Scripts

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)
```

Appendix H – State Variables and Utility Scripts

```
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")
```


Appendix H – State Variables and Utility Scripts

```
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...
```

Appendix H – State Variables and Utility Scripts

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)
    # Pool is rising, reset BaseELEV
    BaseELEV_Cur=WFG_ELEV
    Code=0
    if BaseELEV_Pre < WFG_ELEV:
```

Appendix H – State Variables and Utility Scripts

```
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("WalterFGGeorge_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...
```

Appendix H – State Variables and Utility Scripts

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")
```

Appendix H – State Variables and Utility Scripts

```
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...
```

Appendix H – State Variables and Utility Scripts

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
```

Appendix H – State Variables and Utility Scripts

```
        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

Appendix H – State Variables and Utility Scripts

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 requirement

    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 EI=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)
```

Appendix H – State Variables and Utility Scripts

```
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)
```

Appendix H – State Variables and Utility Scripts

```
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:
```

Appendix H – State Variables and Utility Scripts

```
        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.

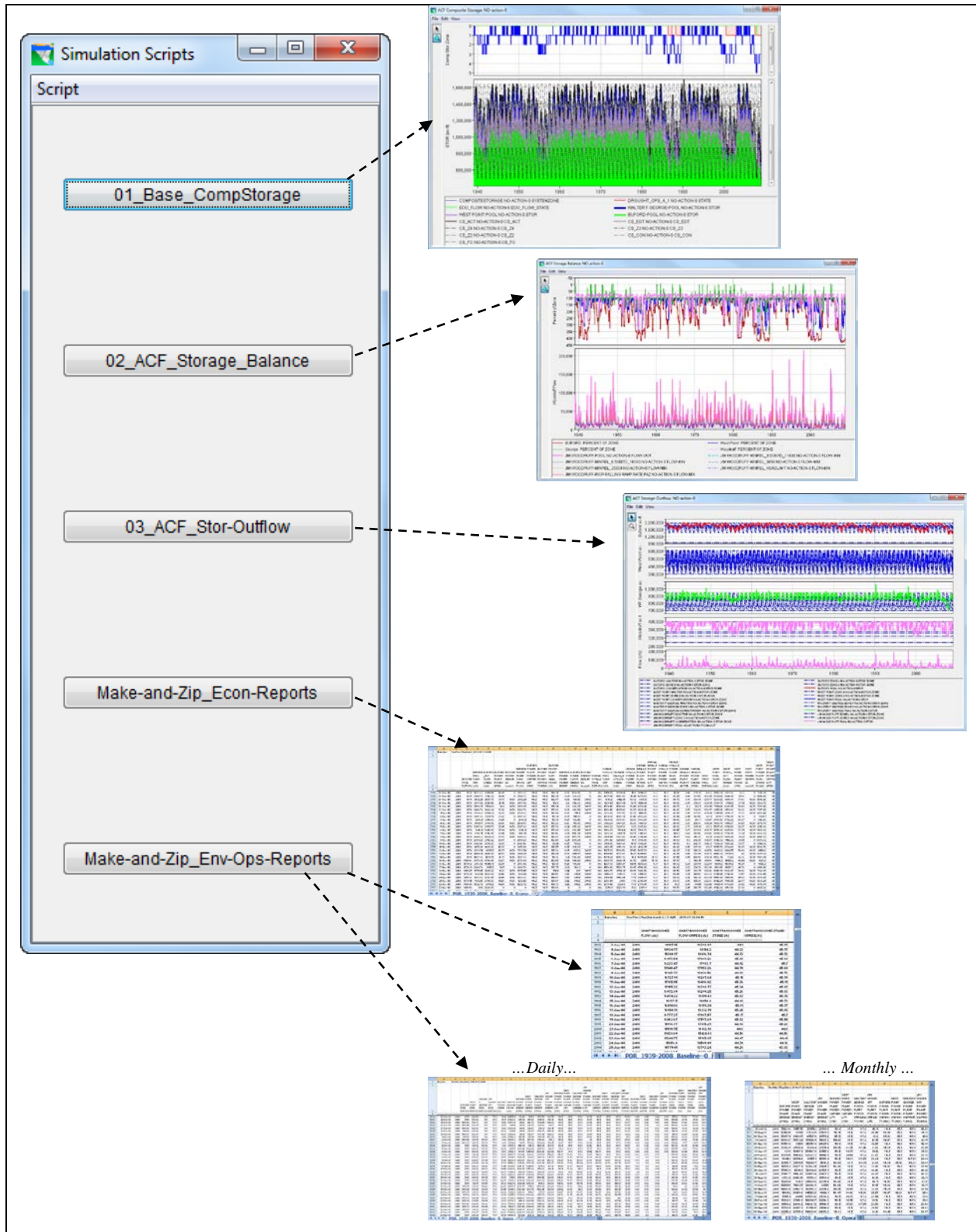


Figure H.26 Scripts in Simulation Module

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

01_Base_CompStorage

Figure H.27 reflects the Script Editor for the plotting script named “01_Base_CompStorage”.

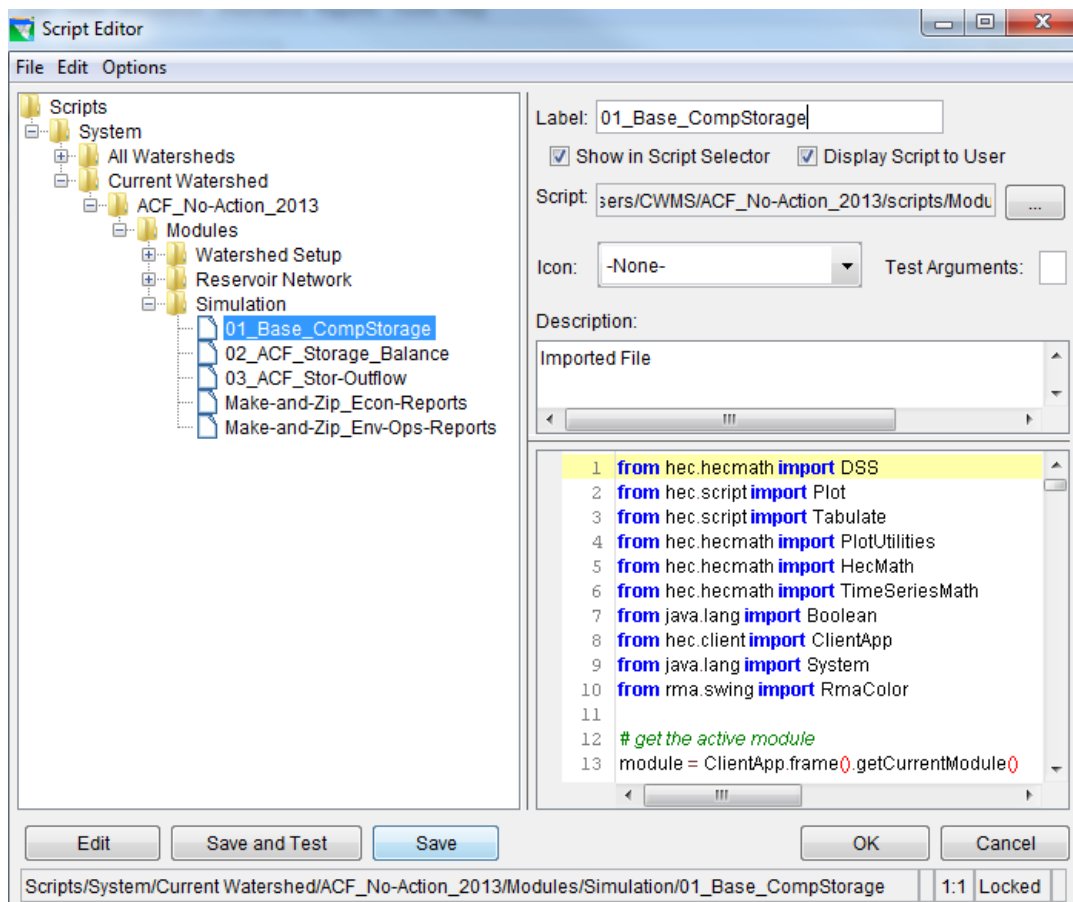


Figure H.27 Script Editor for “01_Base_CompStorage” Plot Script

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”.

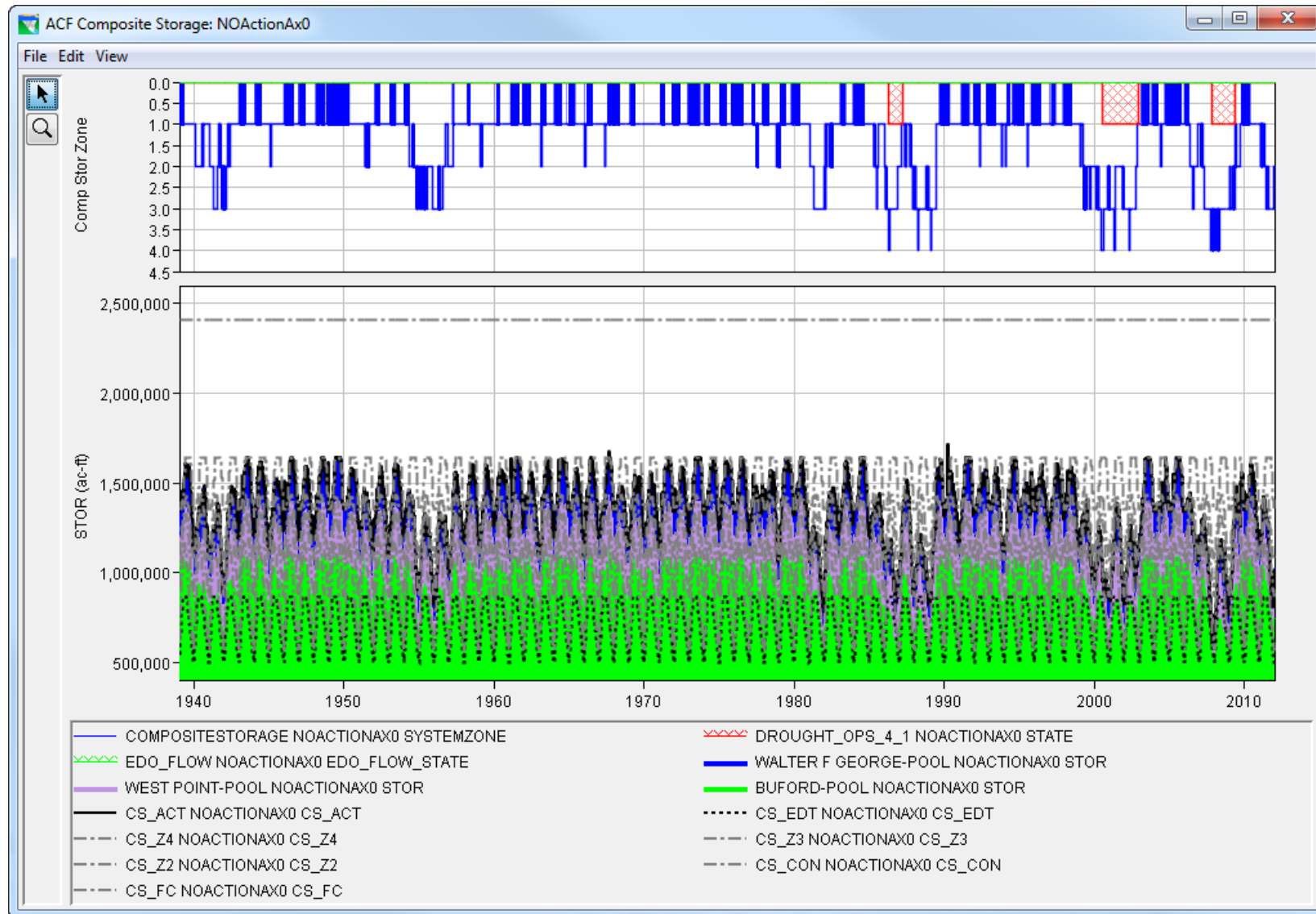


Figure H.28 Plot from “01_Base_CompStorage” Script Showing Period-of-Record “NOActionAx” Results

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 RSimSimulationMode 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

```

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```
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", csIASStorTS.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")

```

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```
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)

vpla = thePlot.getViewport(1)
lyAxis1 = vpla.getAxis("Y1")
lyAxis1.setScaleLimits(400000,1800000)
thePlot.setTitle("ACF Composite Storage: " + runname)
```

2. *ACF_Storage_Balance*

02_ACF_Storage_Balance

Figure H.29 reflects the Script Editor for the plotting script named “02_ACF_Storage_Balance”.

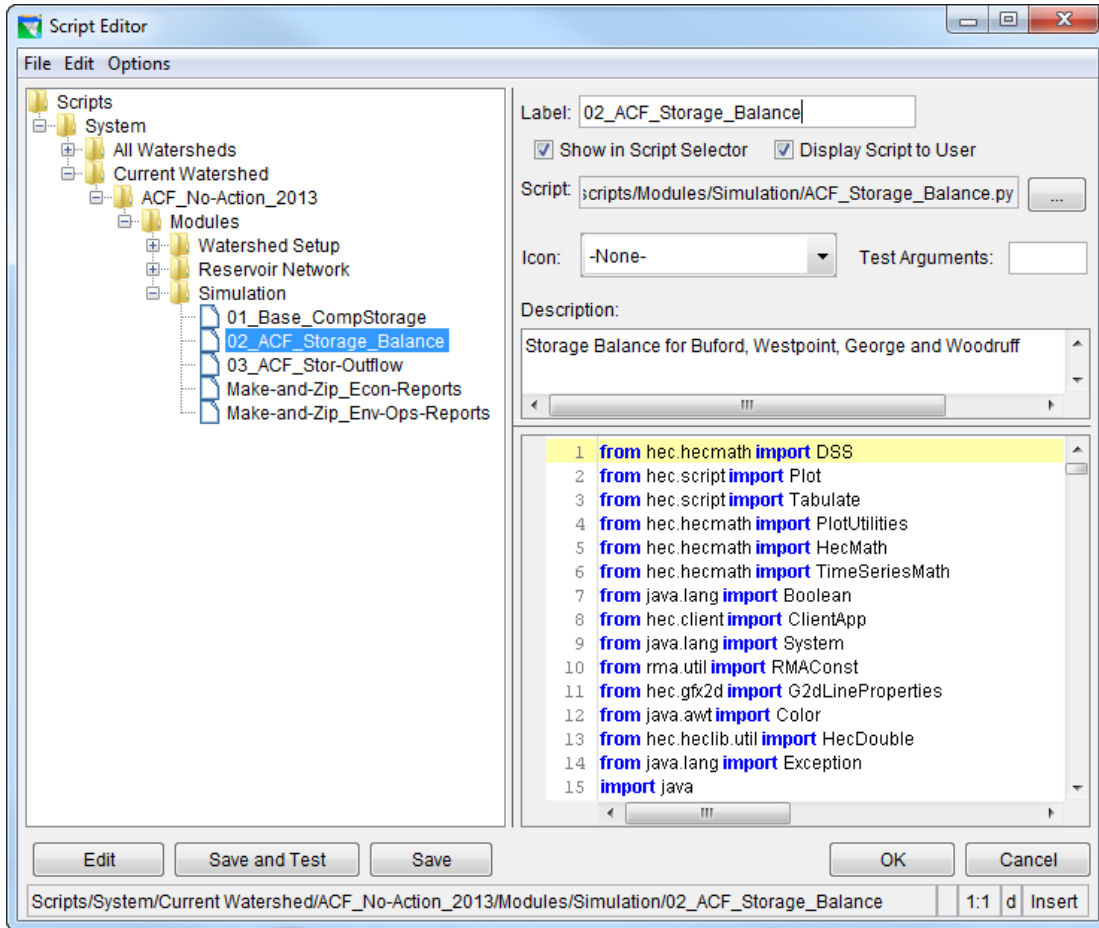


Figure H.29 Script Editor for “02_ACF_Storage_Balance” Plot Script

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”.

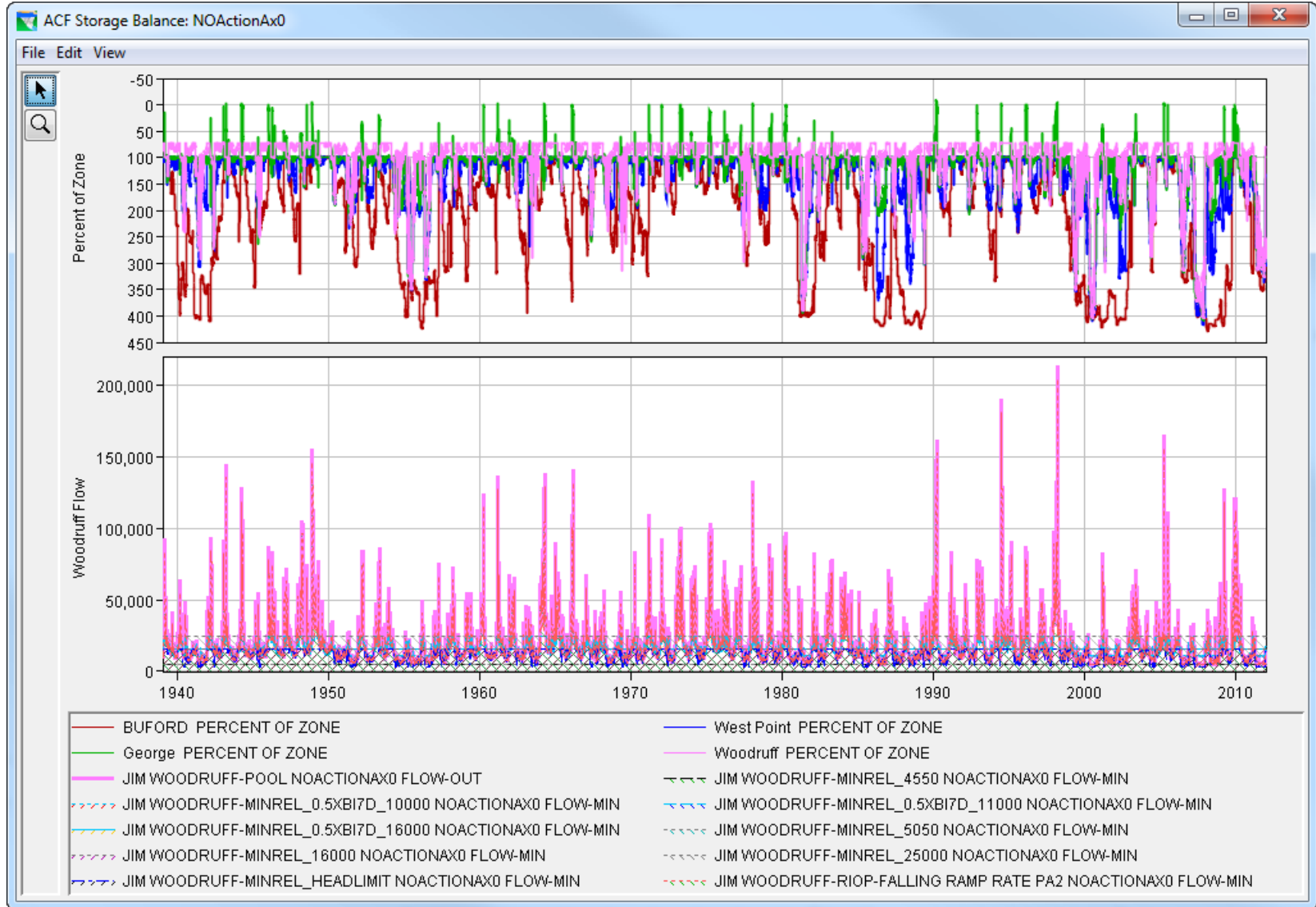


Figure H.30 Plot from “02_ACF_Storage_Balance” Script Showing Period-of-Record “NOActionAx” Results

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())

```

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```
        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 RSimSimulationMode 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)

```

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```
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)

```

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```
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")
```

```
woMR_HeadLimitTSCurve = thePlot.getCurve(woMR_HeadLimitTS)
woMR_HeadLimitTSCurve.setLineColor("Blue")
woMR_HeadLimitTSCurve.setLineWidth(1)
woMR_HeadLimitTSCurve.setLineStyle("Dash Dot")

woMR_RampRateTSCurve = thePlot.getCurve(woMR_RampRateTS)
woMR_RampRateTSCurve.setLineColor("LightRed")
woMR_RampRateTSCurve.setLineWidth(1)
woMR_RampRateTSCurve.setLineStyle("Dot")
#

# set plot title with run name
thePlot.setTitle("ACF Storage Balance: " + runname)
```

3. ACF_Stor-Outflow

03_ACF_Stor-Outflow

Figure H.31 reflects the Script Editor for the plotting script named “03_ACF_Stor-Outflow”.

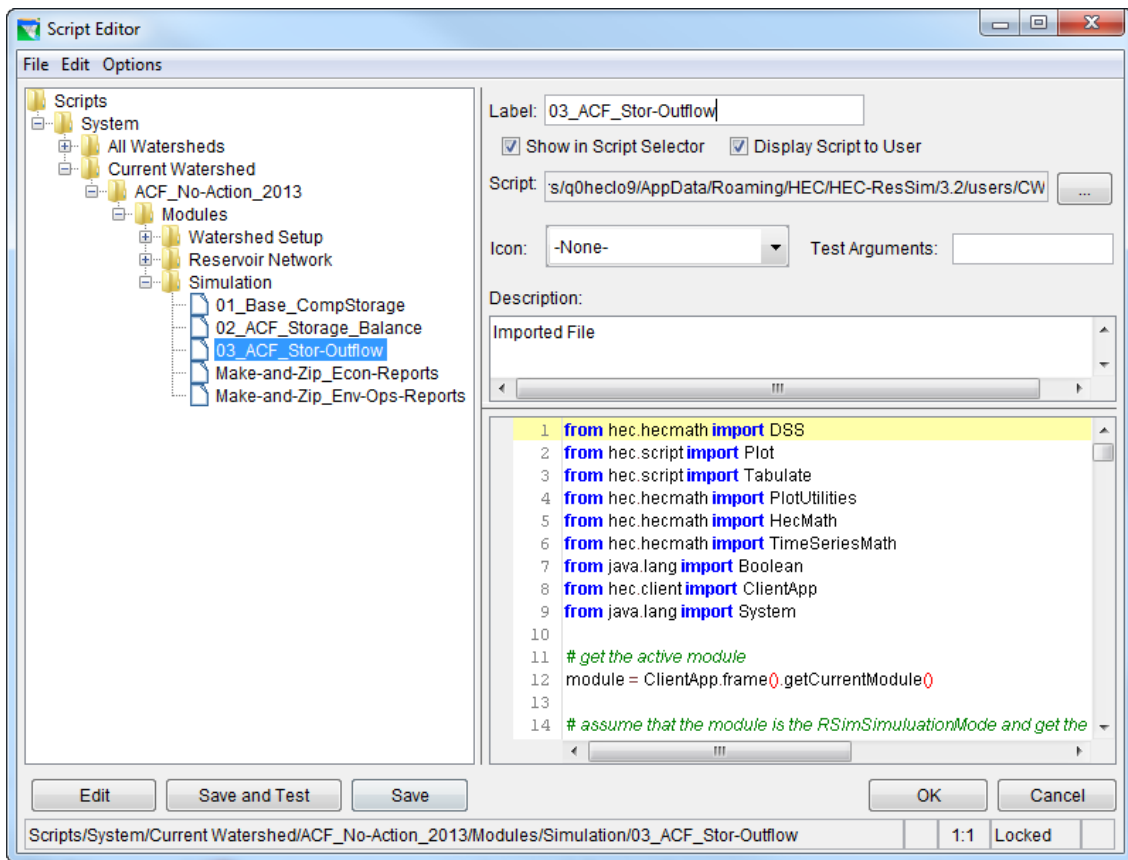


Figure H.31 Script Editor for “03_ACF_Stor-Outflow” Plot Script

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”.

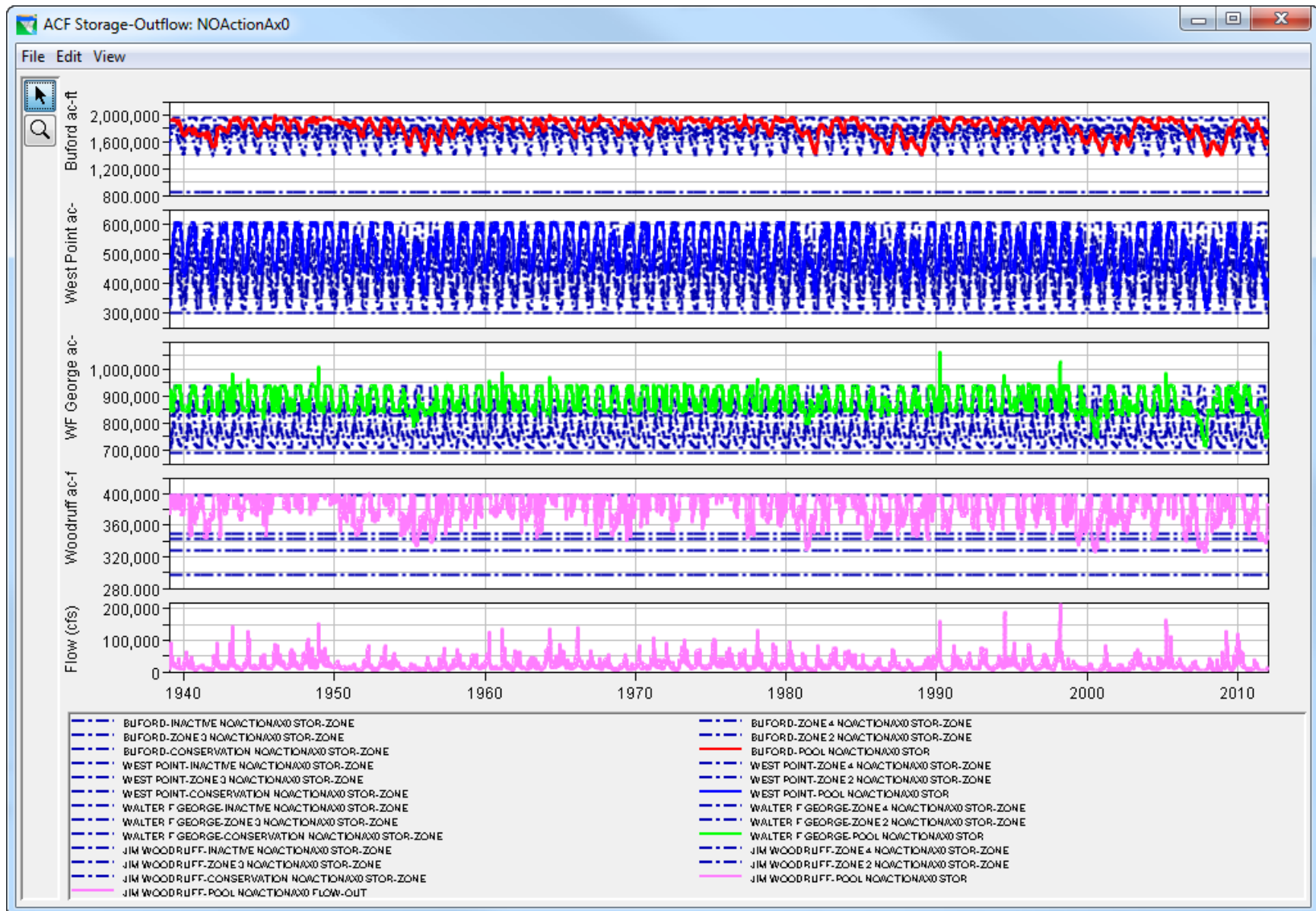


Figure H.32 Plot from “03_ACF_Stor-Outflow” Script Showing Period-of-Record “NOActionAx” Results

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 RSimSimulationMode 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")

```

Appendix H – State Variables and Utility Scripts

```
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.

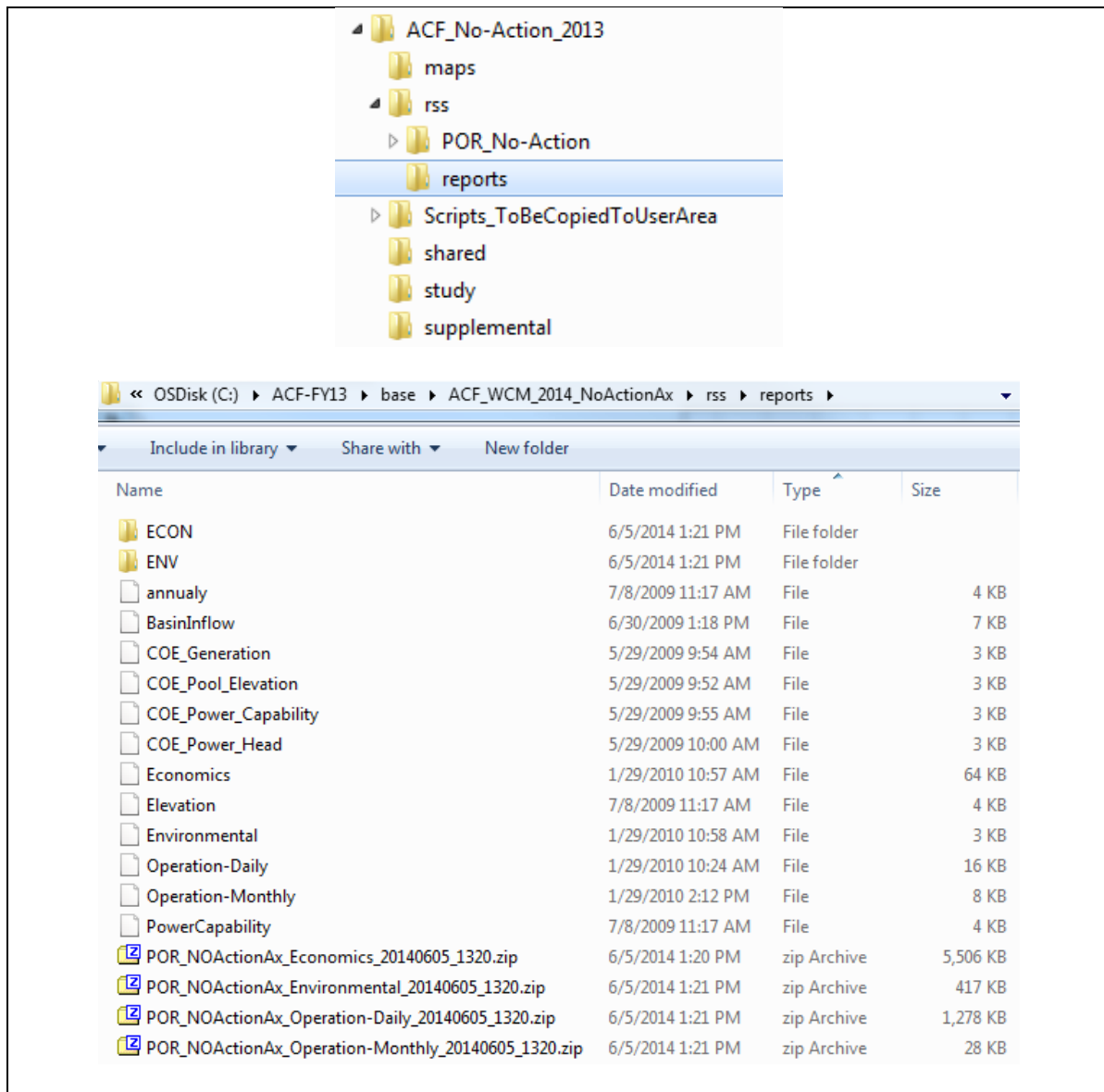


Figure H.33 Folder “reports” with Utility Script Report Templates and Zipped-up Reports Containing Results

Appendix H– State Variables and Utility Scripts

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

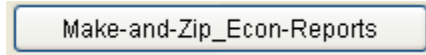


Figure H.34 reflects the Script Editor for the report script named “Make-and-Zip_Econ-Reports”.

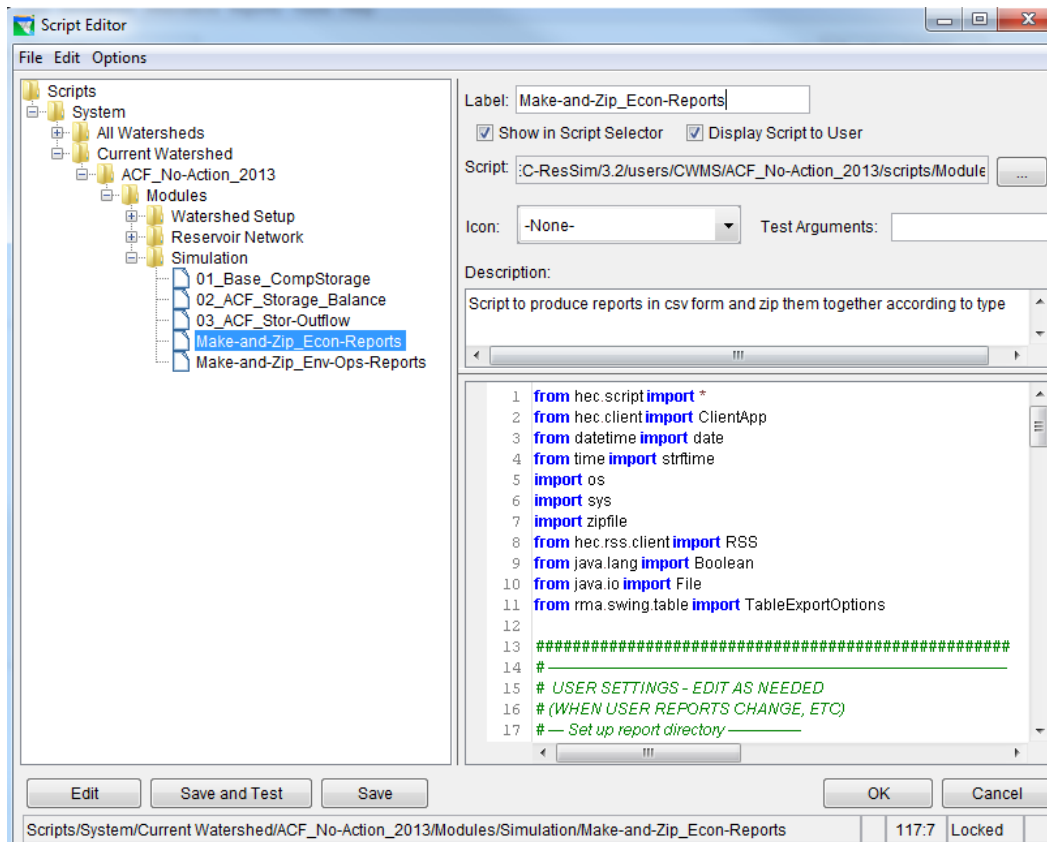


Figure H.34 Script Editor for “Make-and-Zip_Econ-Reports” Report Script

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”.

Appendix H– State Variables and Utility Scripts

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- REQUIRE D (undef)	BUFORD POWER PLANT FLOW- QPOWE R (cfs)	BUFORD POWER PLANT POWER- CAPABILI TY (MW)	BUFORD POWER PLANT POWER- CAPACIT Y (MW)	BUFORD POWER PLANT ELEV- HEAD POWER (ft)	BUFORD POWER PLANT PLANTFA CTOR	BUFORD POWER PLANT ENERGY (MWh)	BUFORD ENERGY- REQUIRE D (undef)	MORGAN FALLS POOL ELEV (ft)	MORGAN FALLS POOL FLOW- OUT (cfs)	MORGAN FALLS_O UT 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) :

```

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```
# 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 current 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

Make-and-Zip_Env-Ops-Reports

Figure H.36 reflects the Script Editor for the report script named “Make-and-Zip_Env-Ops-Reports”.

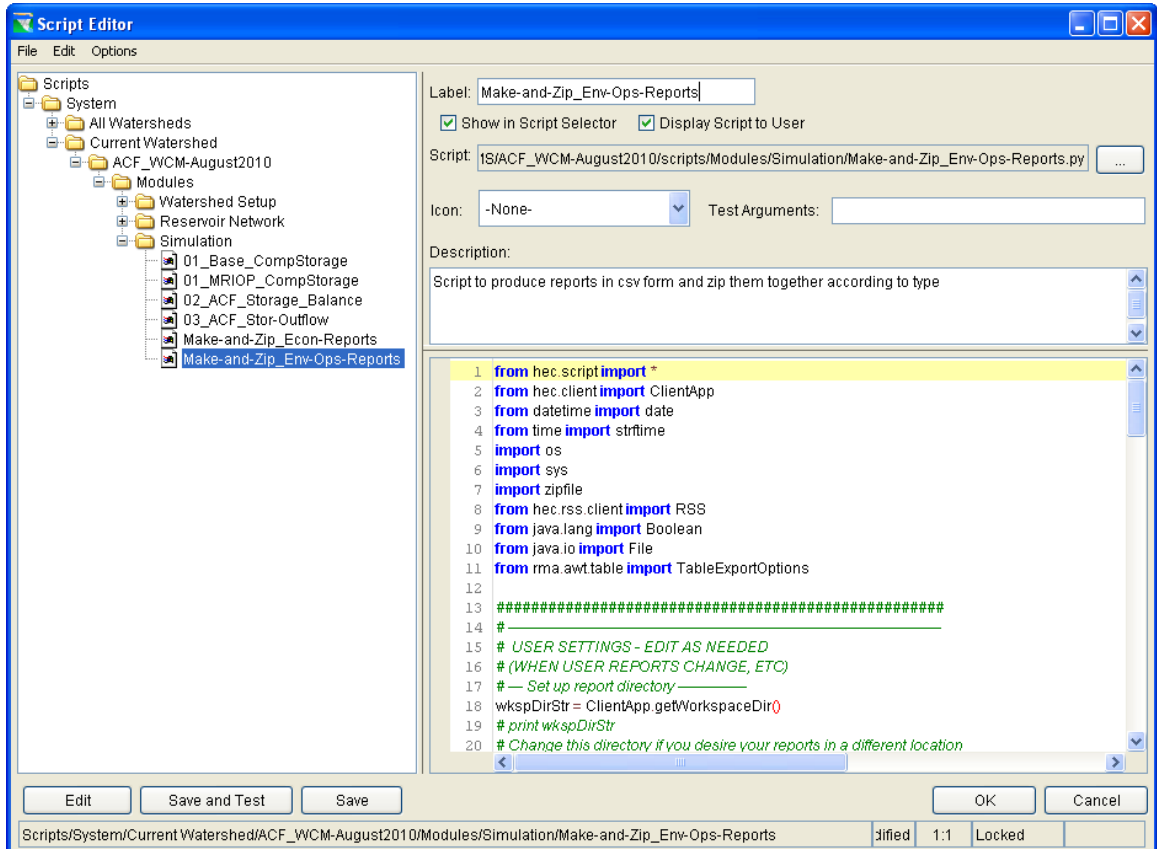


Figure H.36 Script Editor for “Make-and-Zip_Env-Ops-Reports” Report Script

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”.

Appendix H- State Variables and Utility Scripts

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

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 OCHEE 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- CAPABI TY (MW)	WEST POINT POWER PLANT POWER- CAPABI TY (MW)	WALTER F GEORGE POWER PLANT POWER- CAPABI 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

Figure H.38 Example Snapshot from Report “POR_NOActionAx0_Operation-Daily” Containing “NOActionAx” Period-of-Record Results

Appendix H- State Variables and Utility Scripts

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 WOODR UFF POWER PLANT ENERGY (MWh)	BUFORD POWER PLANT POWER- CAPABI TY (MW)	WEST POINT POWER PLANT POWER- CAPABI TY (MW)	WALTER F GEORGE POWER PLANT POWER- CAPABI TY (MW)	JIM WOODR UFF POWER PLANT POWER- CAPABI TY (MW)	BUFORD POWER PLANT POWER- CAPACIT Y (MW)	WEST POINT POWER PLANT POWER- CAPACIT Y (MW)	WALTER F GEORGE POWER PLANT POWER- CAPACIT Y (MW)	JIM WOODR UFF POWER PLANT POWER- CAPACIT Y (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

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
# -----

```

Appendix H- State Variables and Utility Scripts

```
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 current 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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Appendix I – Flood Modeling

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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.

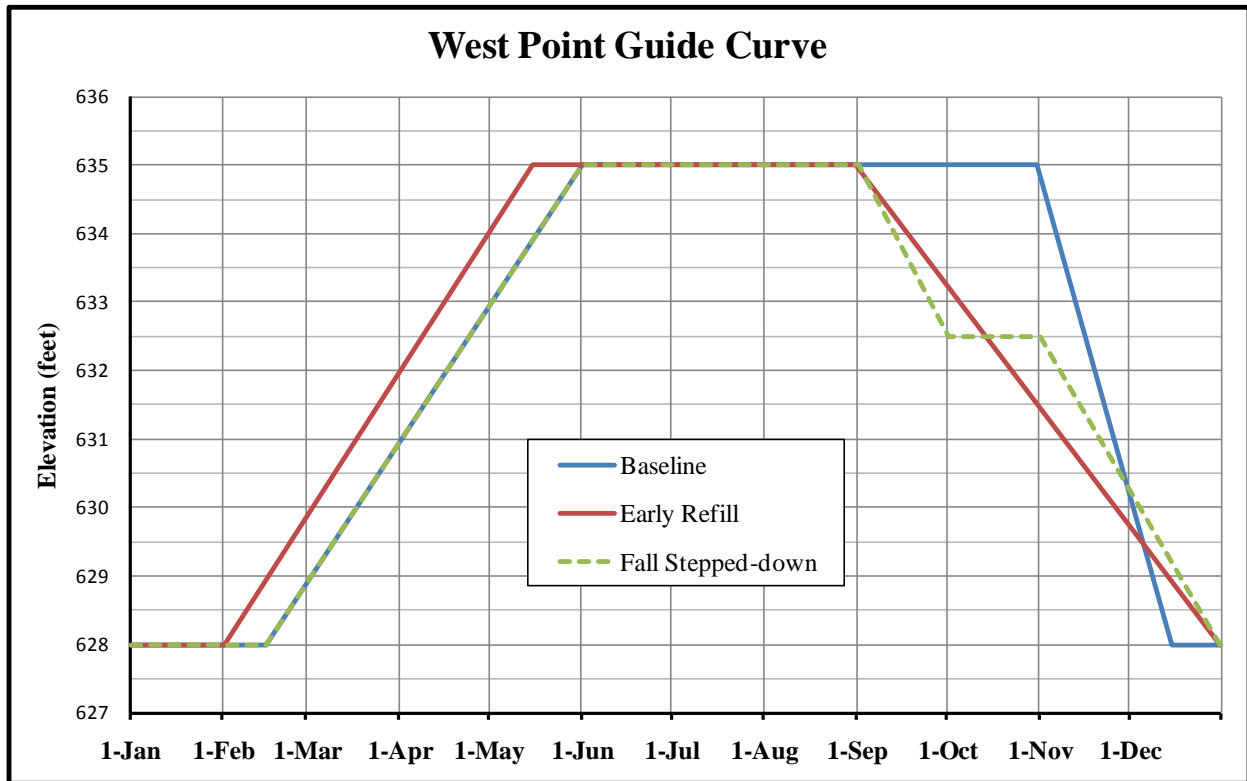


Figure I.01 West Point Guide Curve – Three Operation Sets (Baseline, Early Refill, and Fall Stepped-Down)

Appendix I – Flood Modeling

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.

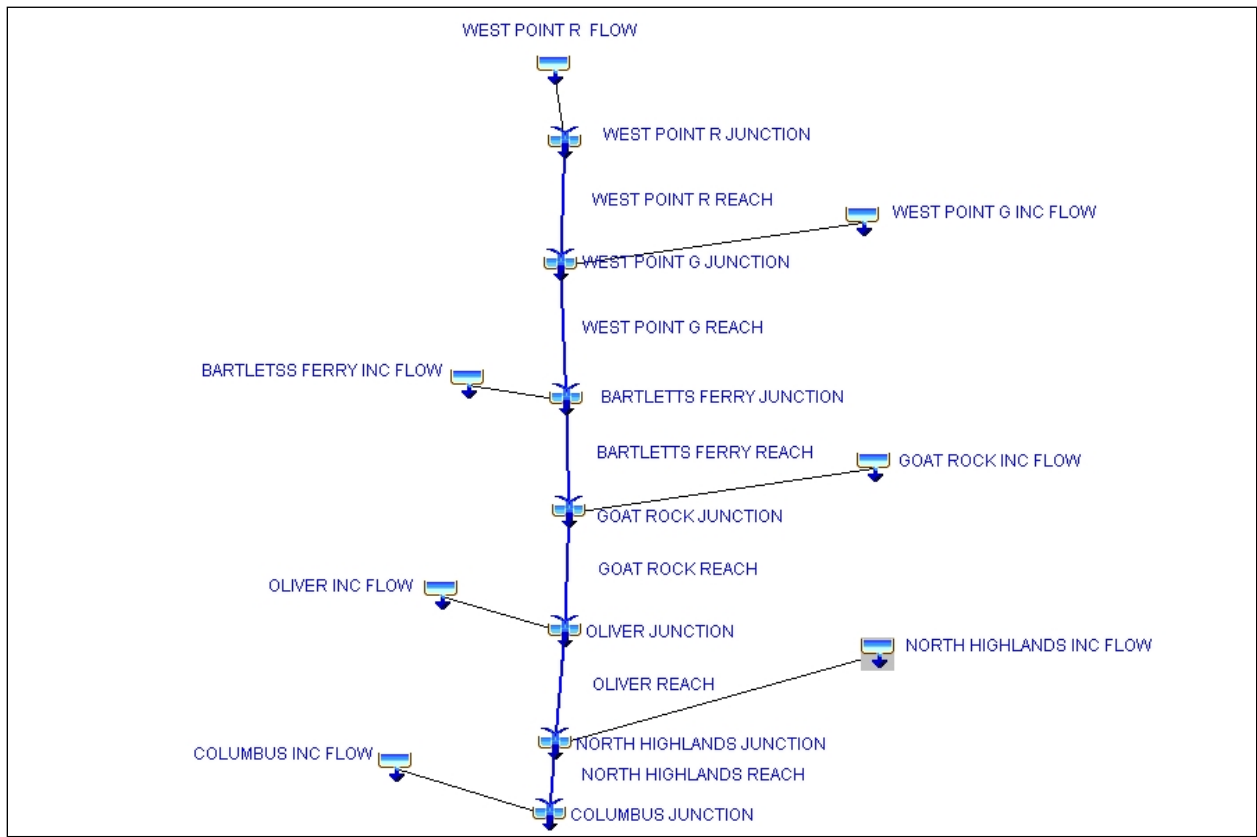


Figure I.02 Schematic of HEC-HMS Model

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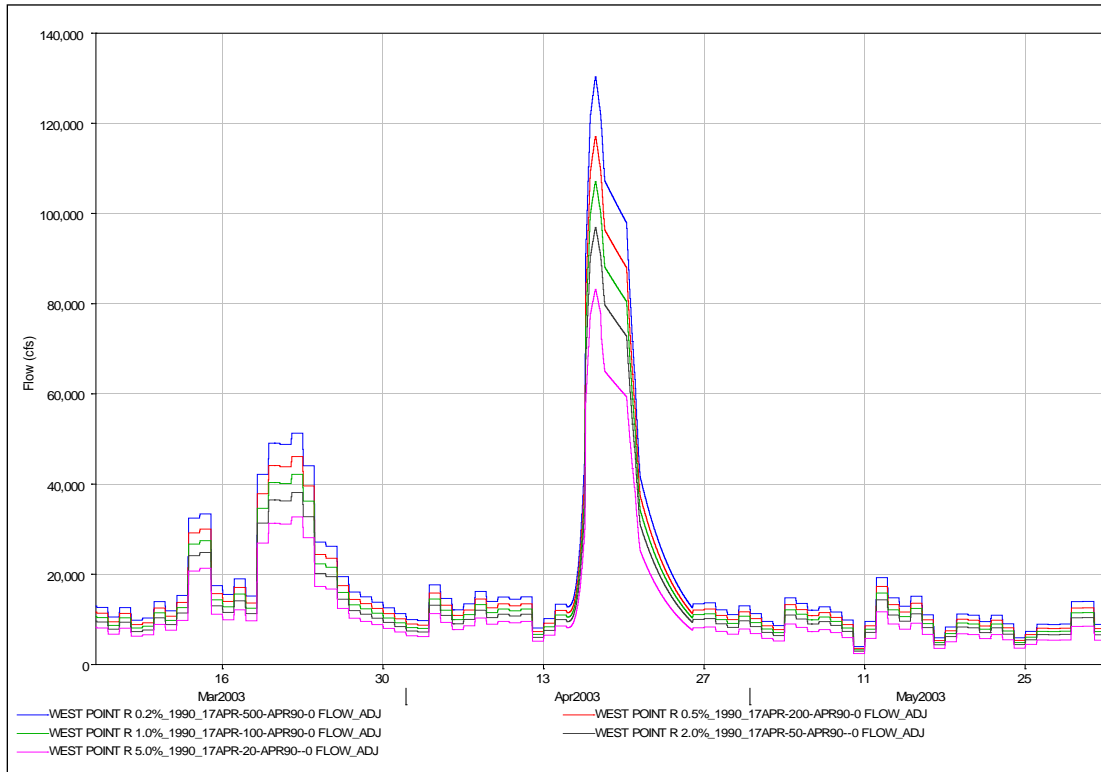


Figure I.03 Hypothetical Hydrographs at West Point Based on Shapes of March 1990 Hydrographs

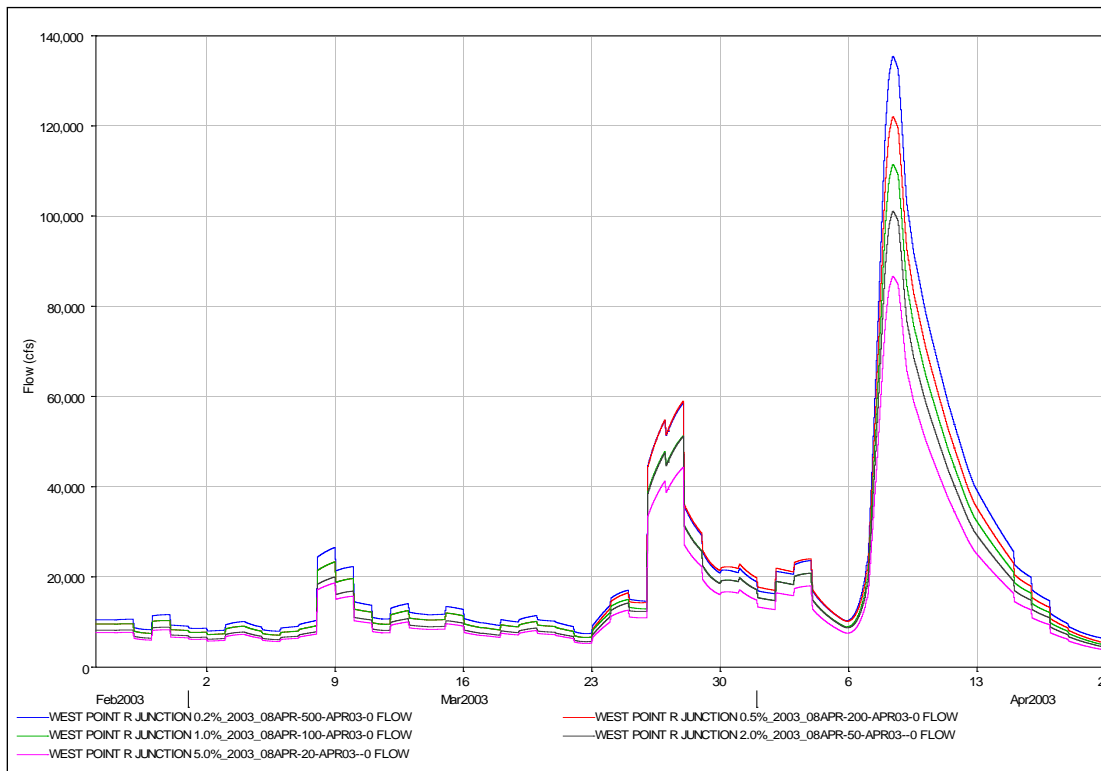


Figure I.04 Hypothetical Hydrographs at West Point Based on Shapes of May 2003 Hydrographs

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

¹Note: 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.

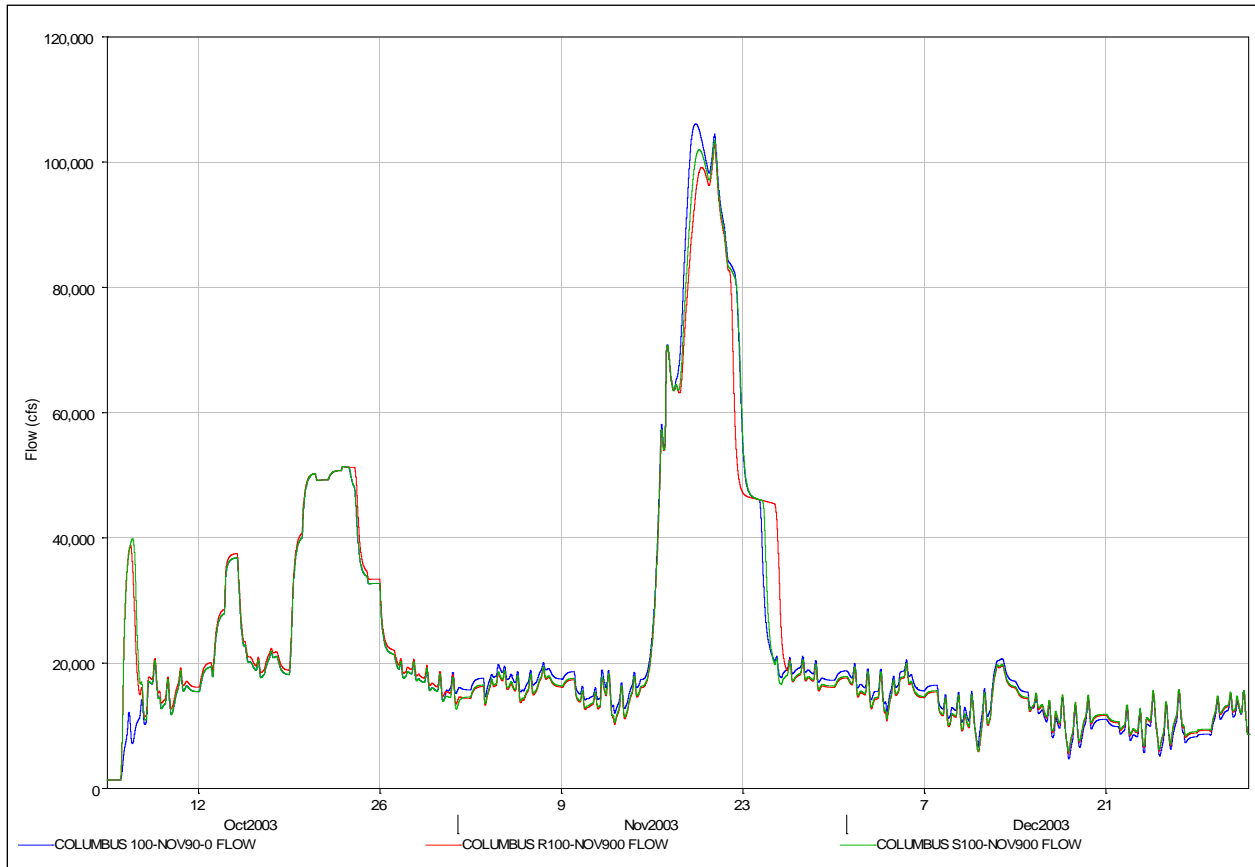


Figure I.05 Regulated November 1% Storm Hydrographs for the Baseline, Early Refill, and Fall Stepped-down Conditions (based on March 1990 hydrograph shapes).

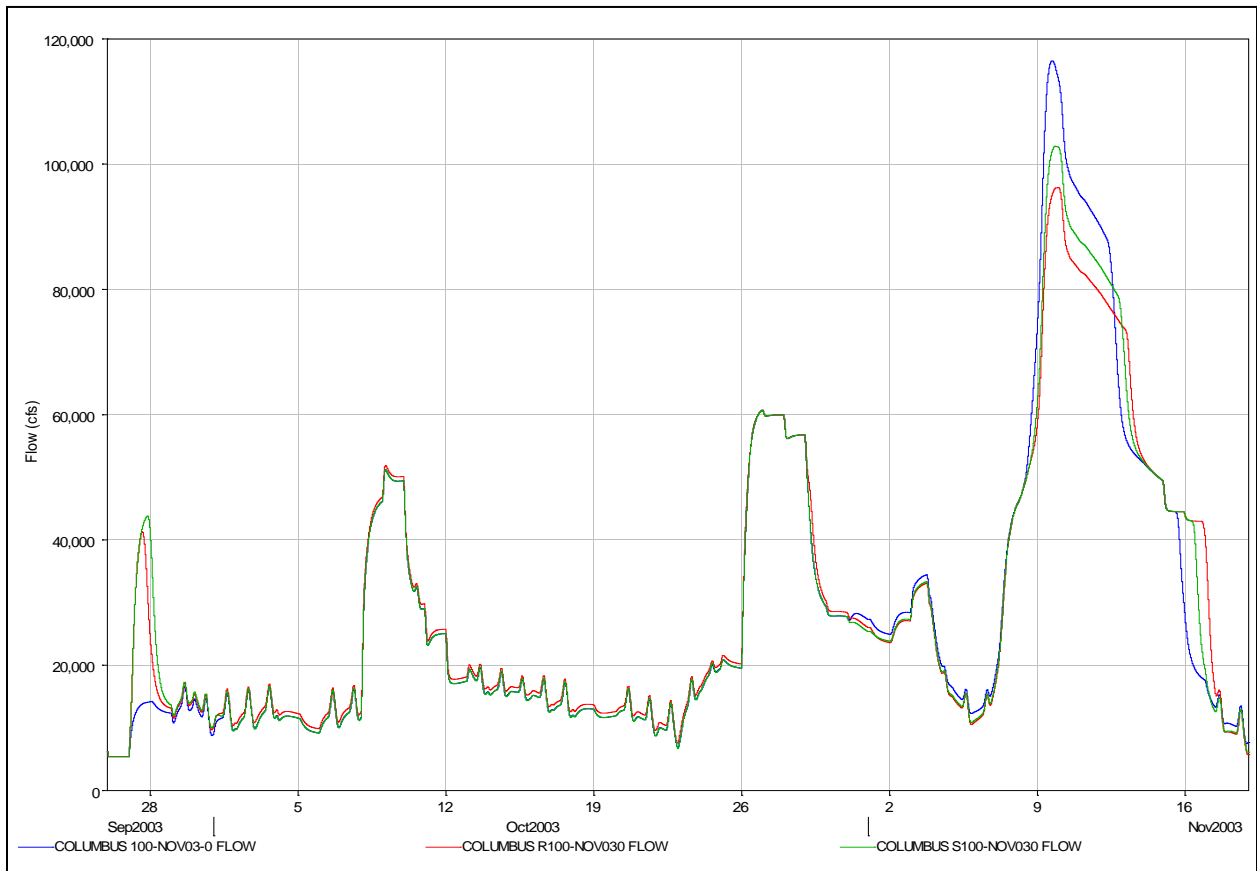


Figure I.06 Regulated November 1% Storm Hydrographs for the Baseline, Early Refill, and Fall Stepped-down Conditions (based on May 2003 hydrograph shapes).

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.

Appendix I – Flood Modeling

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 ...

Appendix I – Flood Modeling

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).

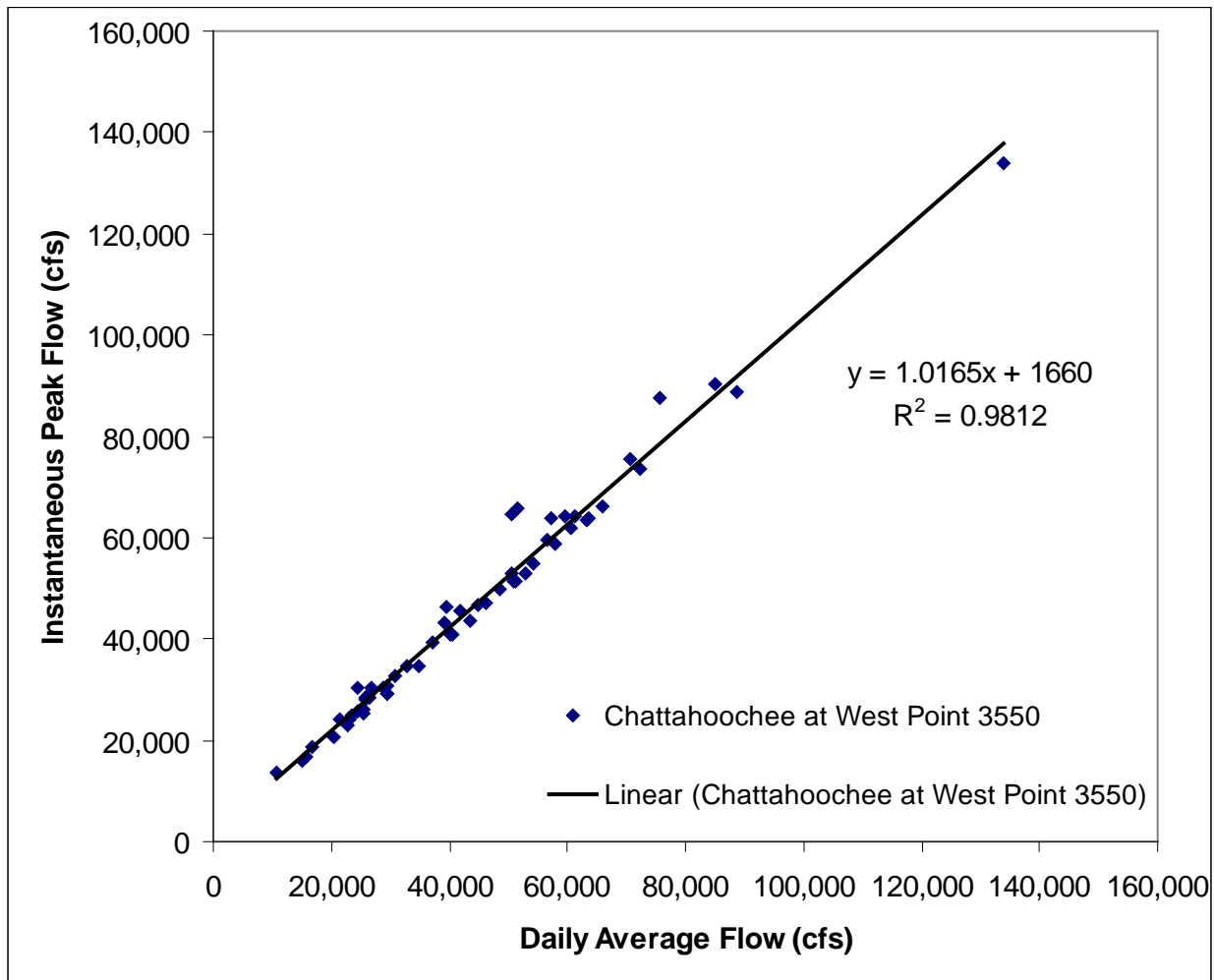


Figure I.07 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage (U.S. Army Corps of Engineers, 2009).

Appendix I – Flood Modeling

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.

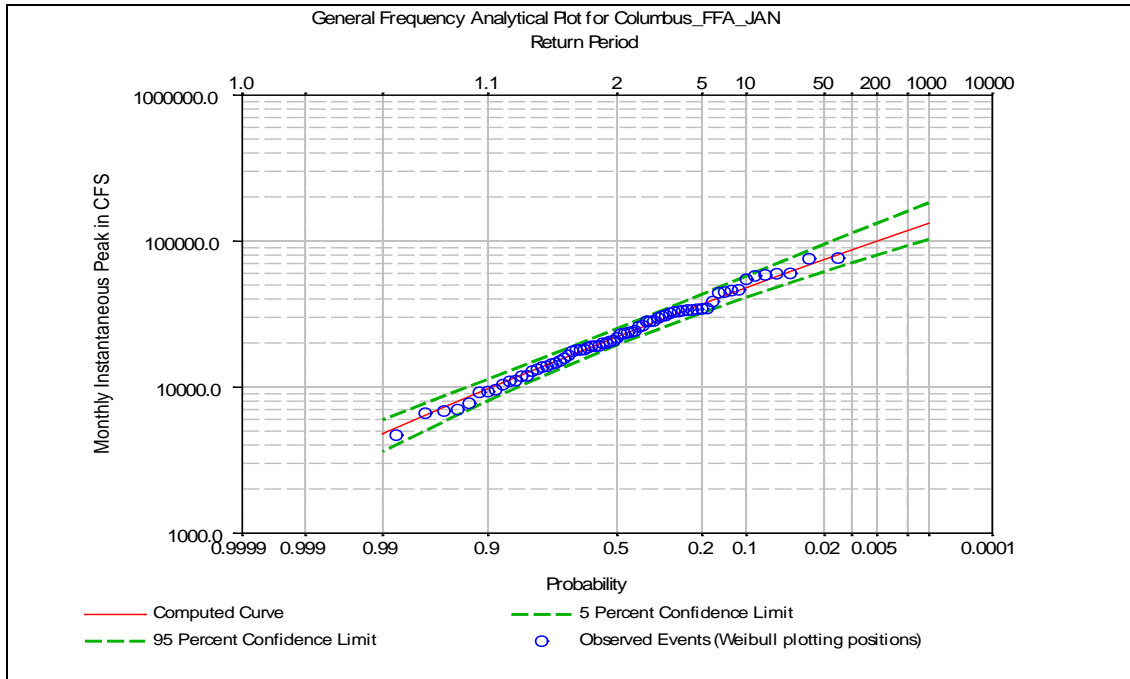


Figure I.08 January Unregulated Flood Frequency Curve

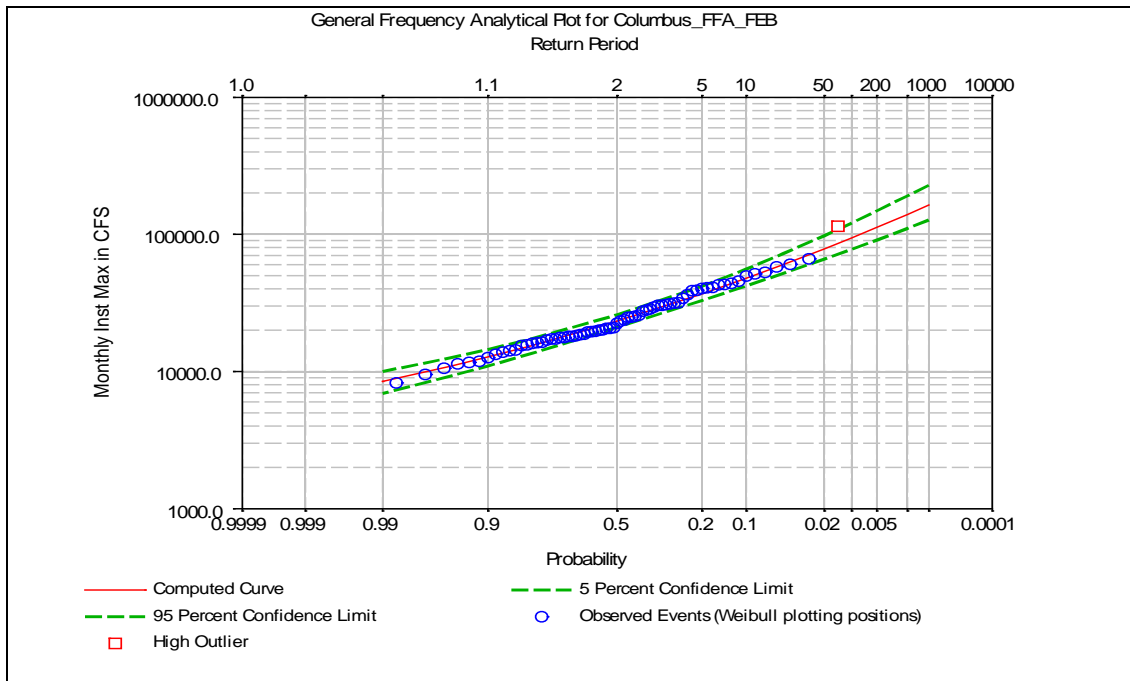


Figure I.09 February Unregulated Flood Frequency Curve

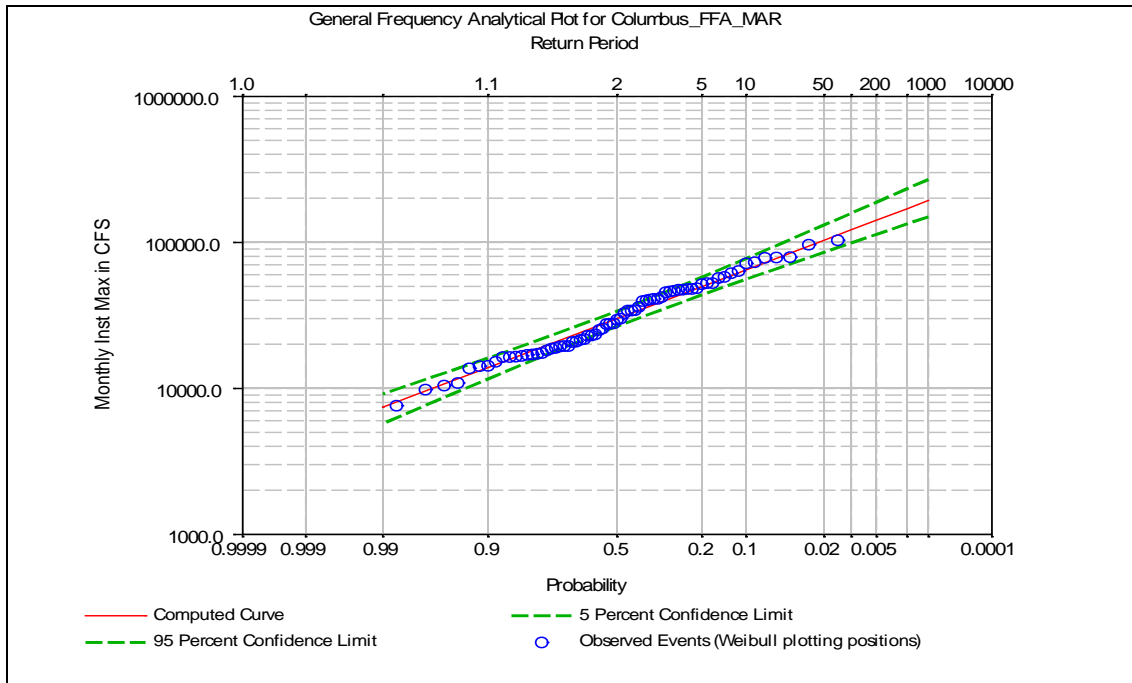


Figure I.10 March Unregulated Flood Frequency Curve

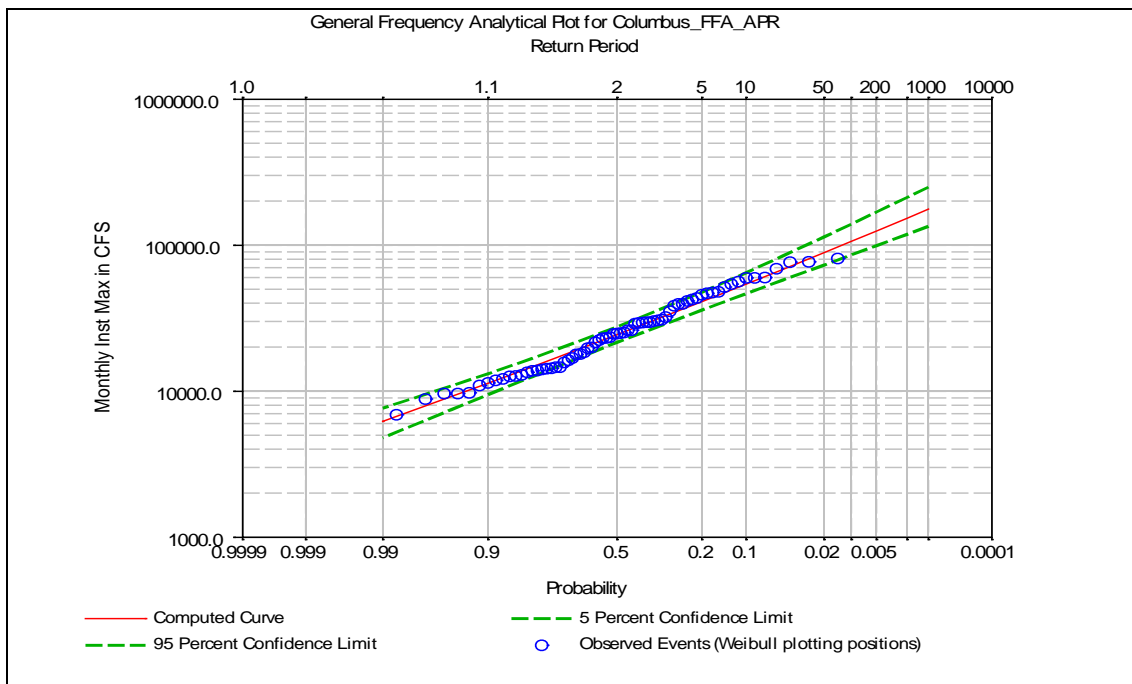


Figure I.11 April Unregulated Flood Frequency Curve

Appendix I – Flood Modeling

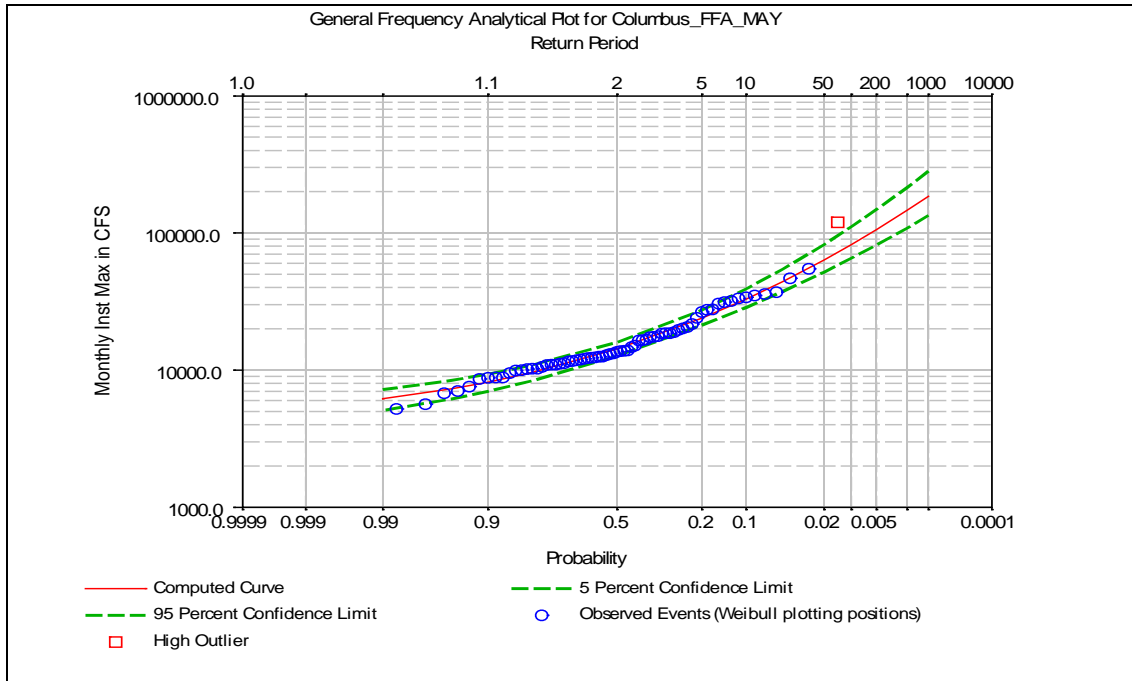


Figure I.12 May Unregulated Flood Frequency Curve

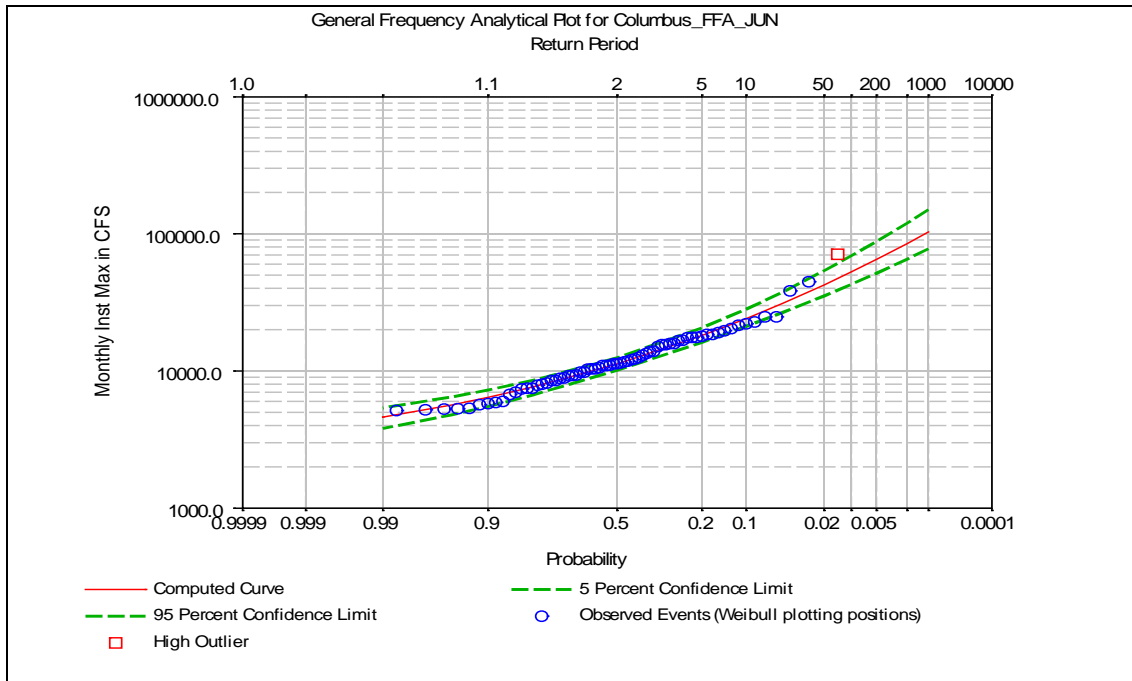


Figure I.13 June Unregulated Flood Frequency Curve

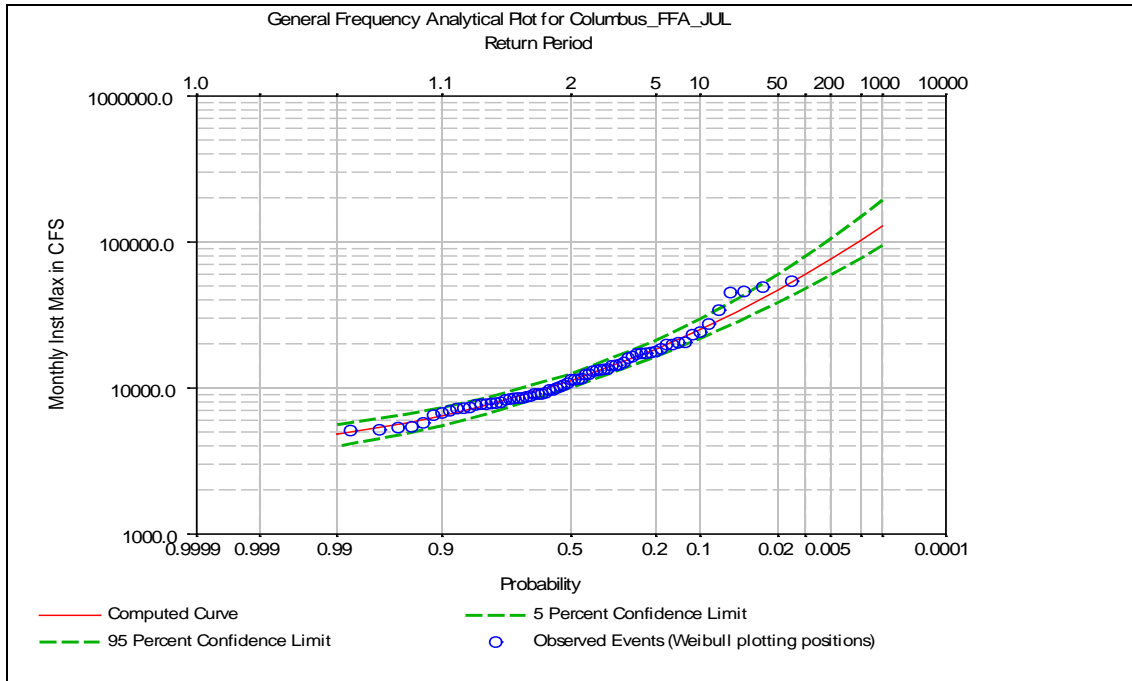


Figure I.14 July Unregulated Flood Frequency Curve

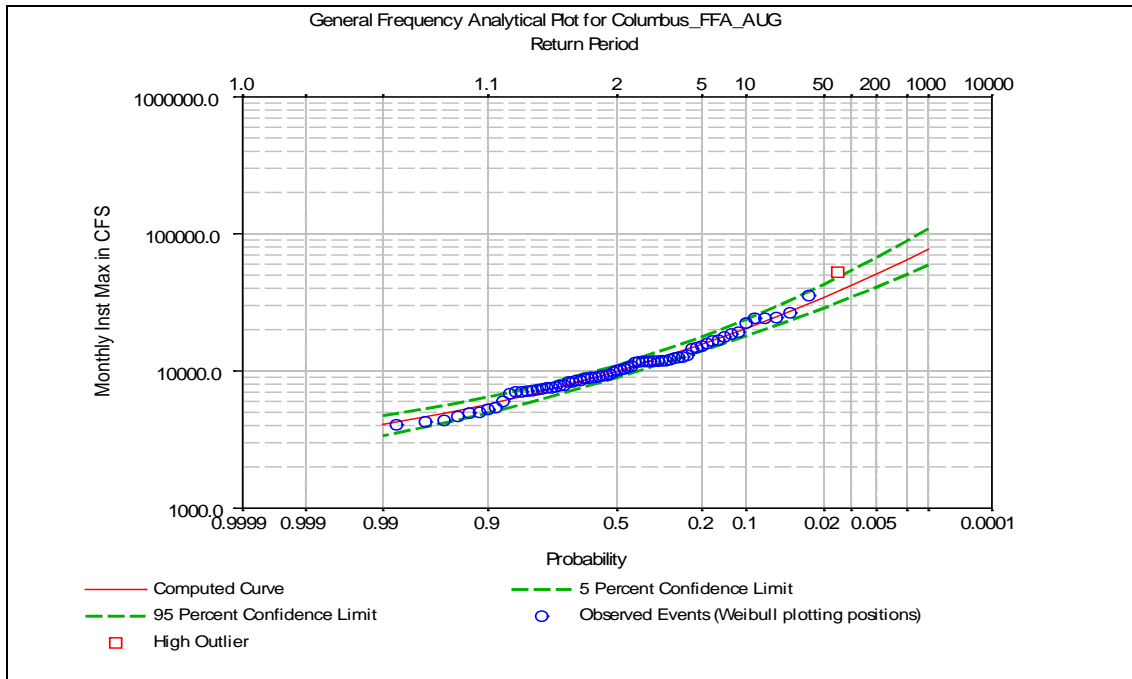


Figure I.15 August Unregulated Flood Frequency Curve

Appendix I – Flood Modeling

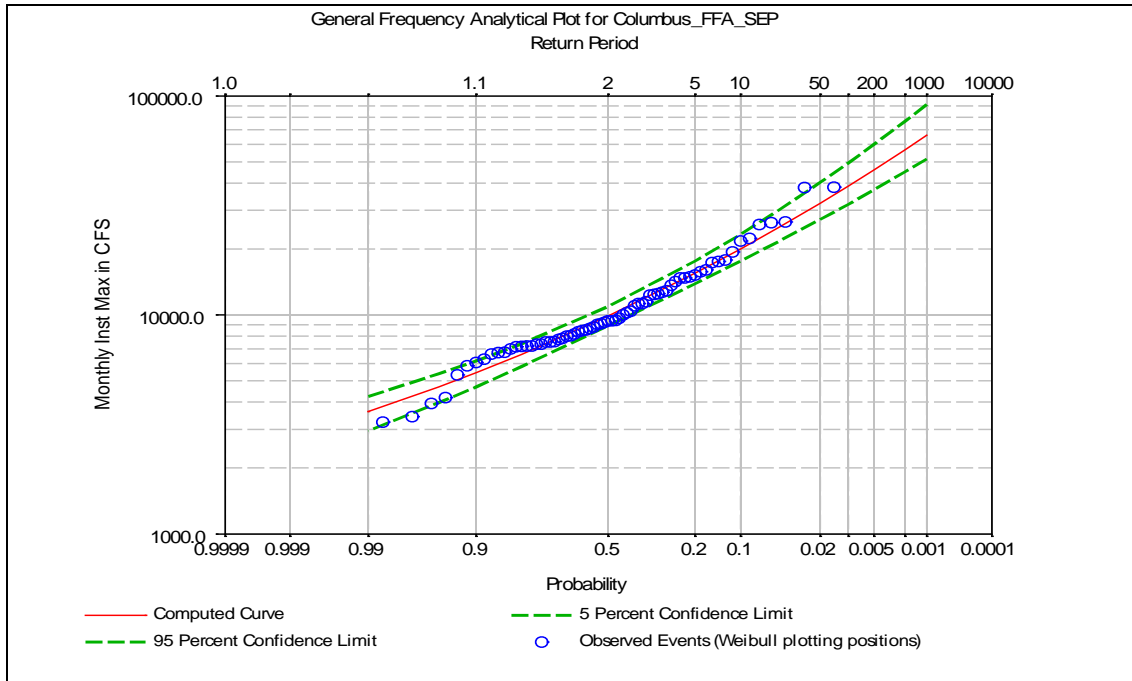


Figure I.16 September Unregulated Flood Frequency Curve

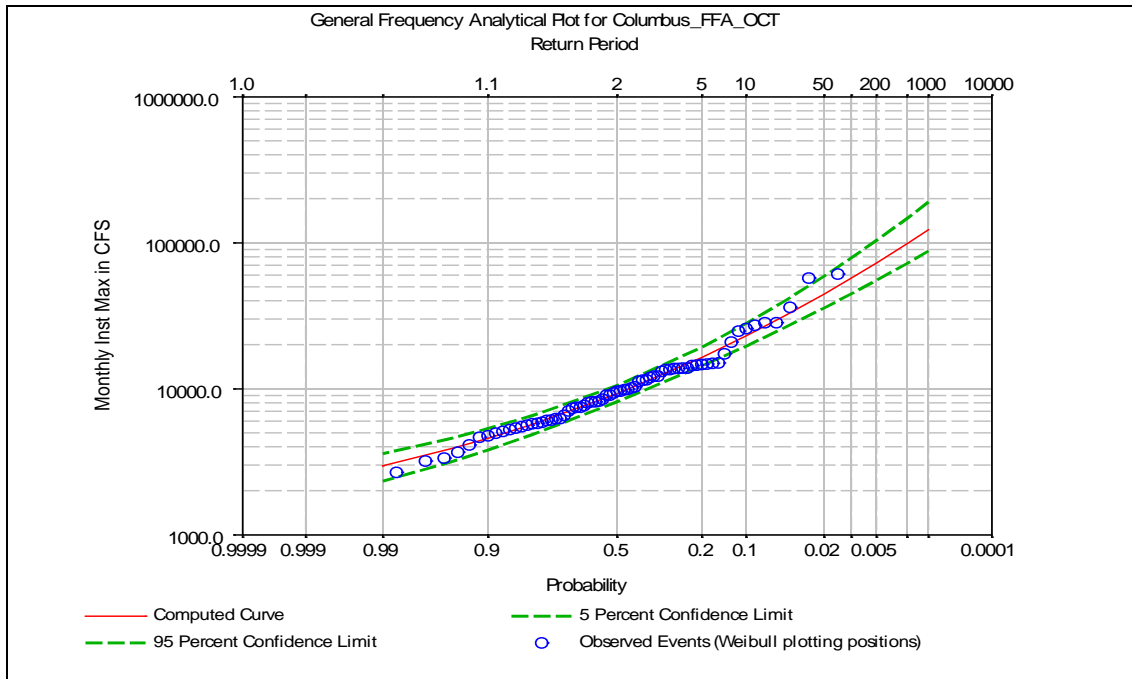


Figure I.17 October Unregulated Flood Frequency Curve

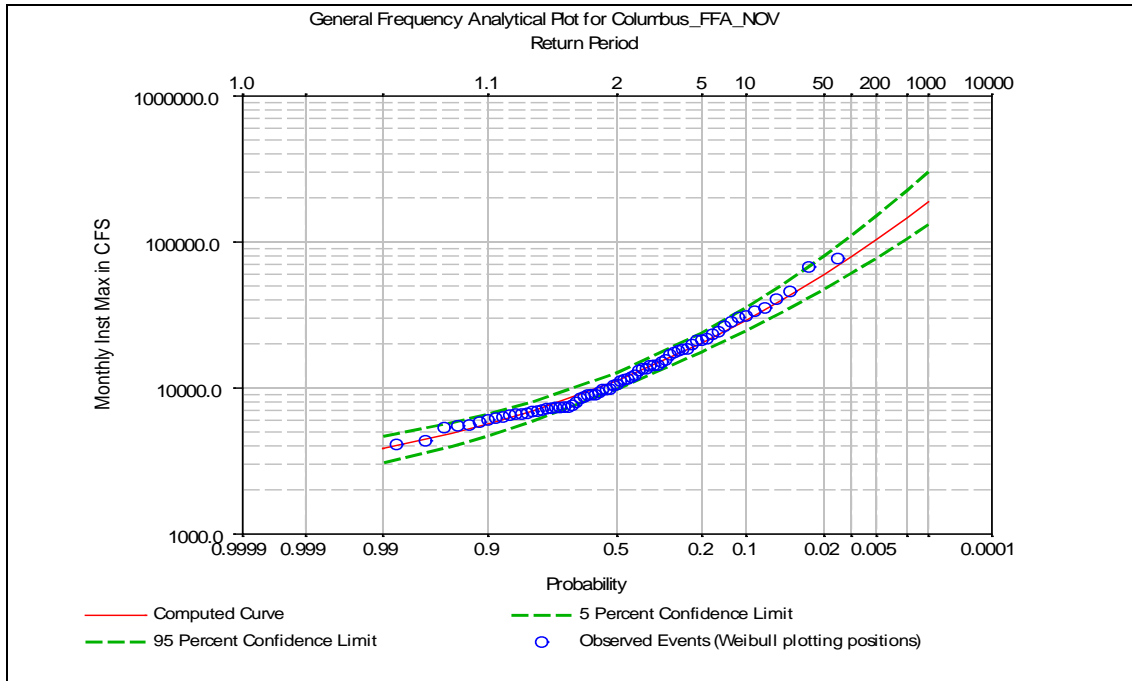


Figure I.18 November Unregulated Flood Frequency Curve

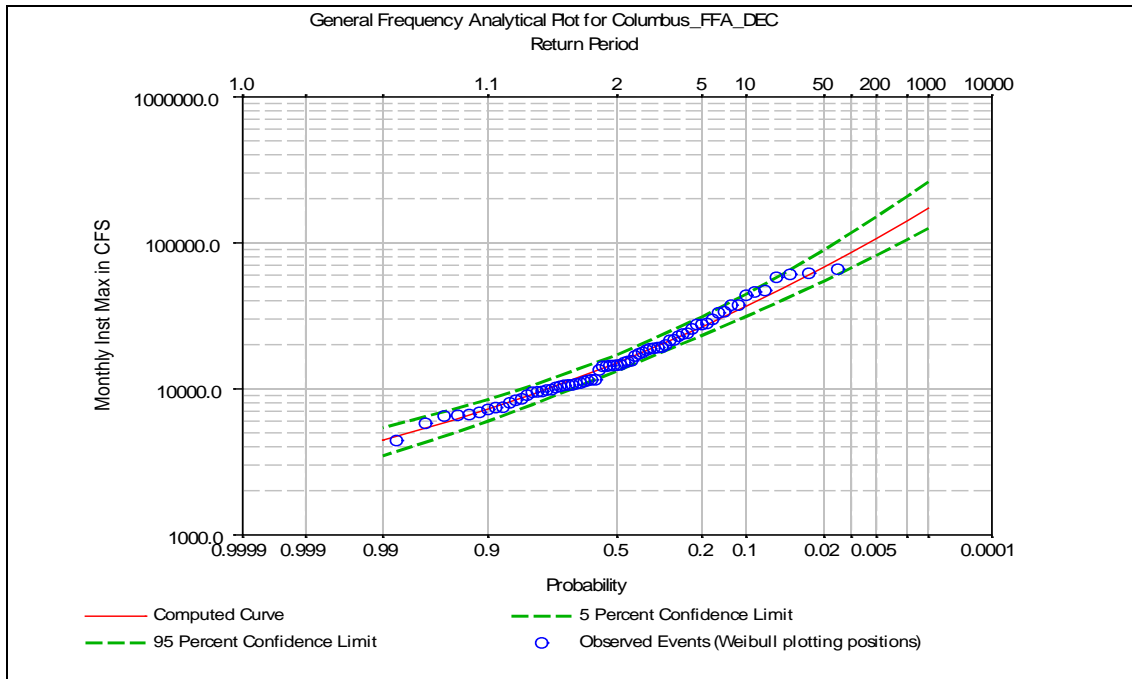


Figure I.19 December Unregulated Flood Frequency Curve

Appendix I – Flood Modeling

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.

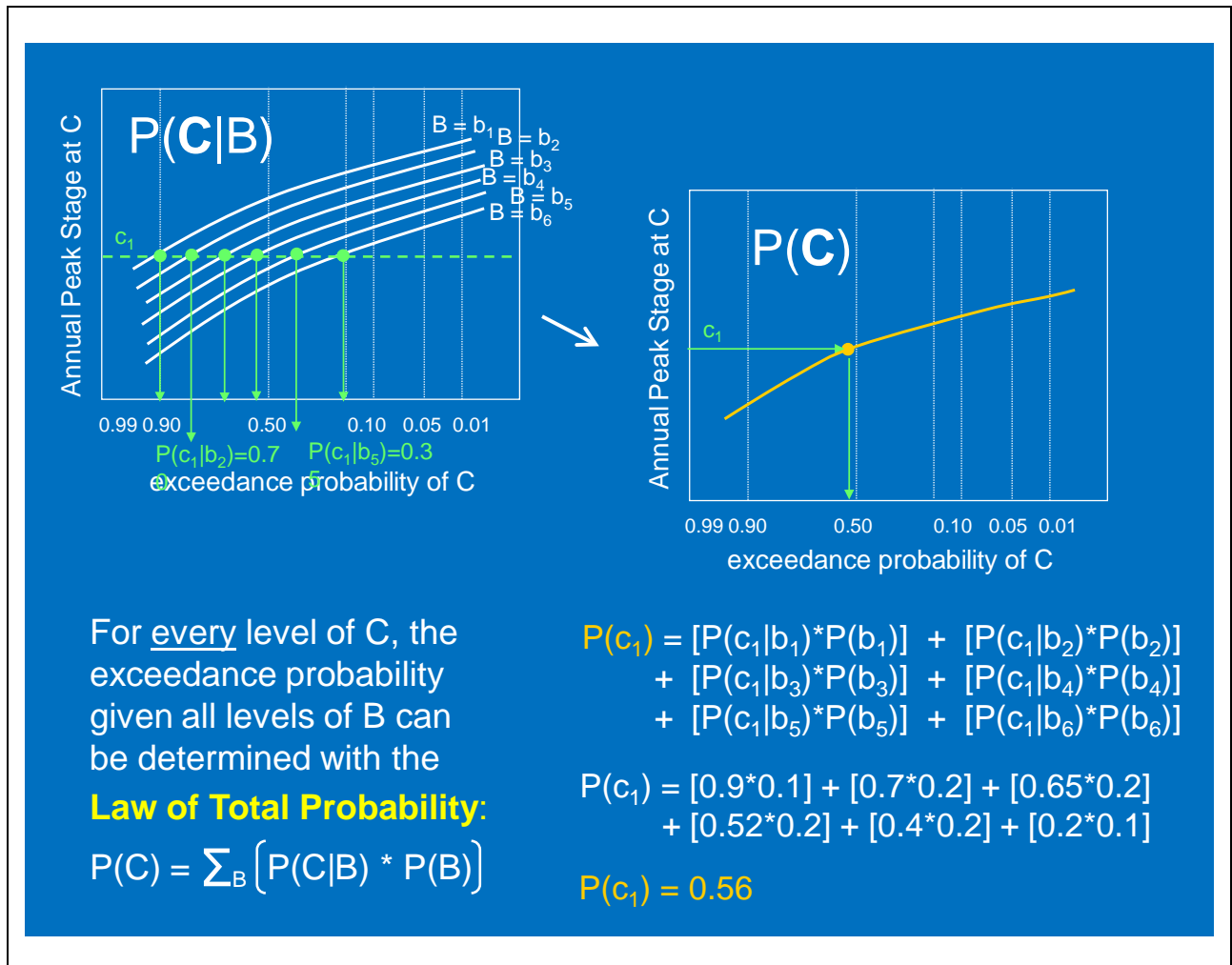


Figure I.20 Example of Total Probability Calculation

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

Appendix I – Flood Modeling

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.

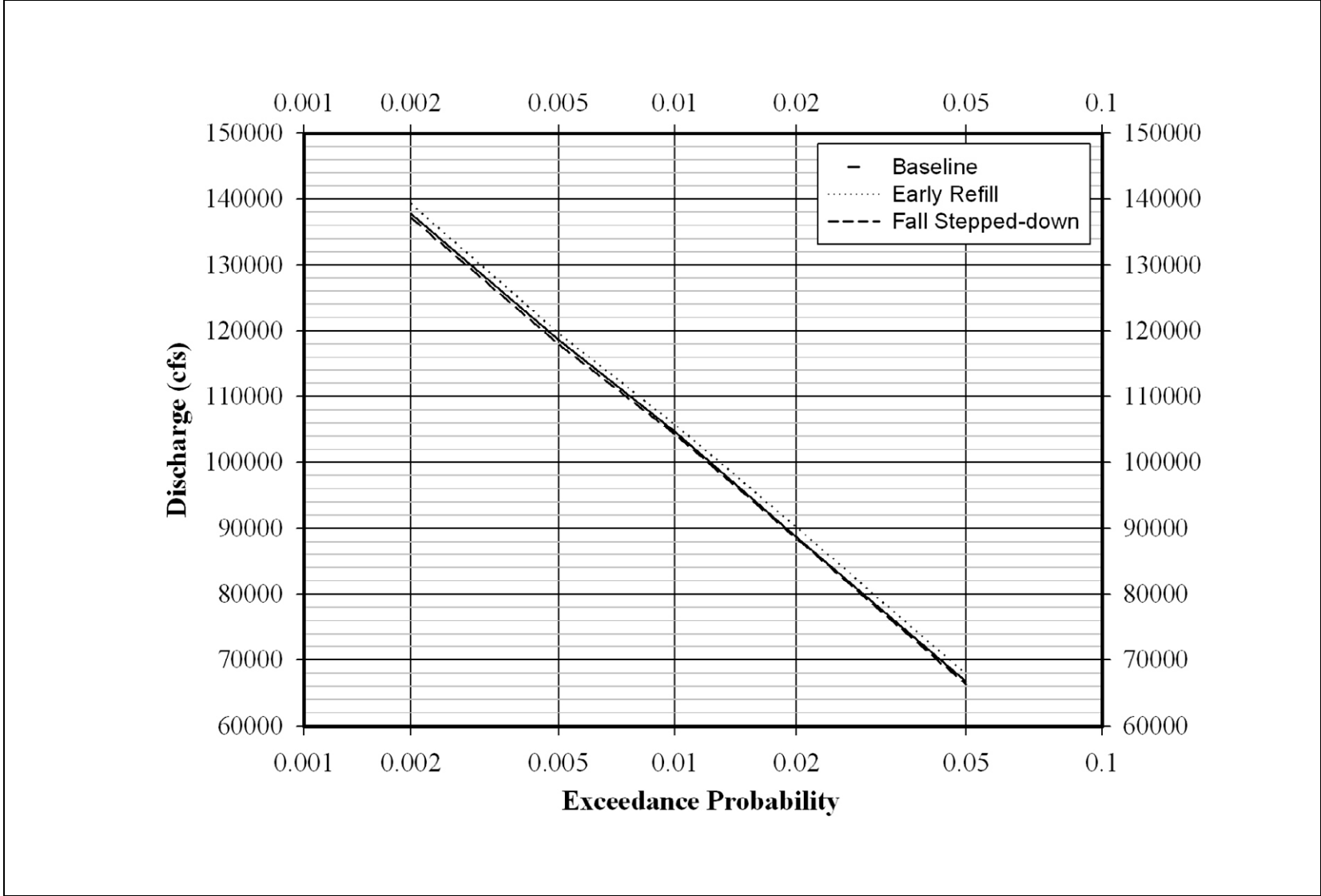


Figure I.21 Combined Flood Frequency Curves at Columbus Based on March 1990 Hydrograph Shapes

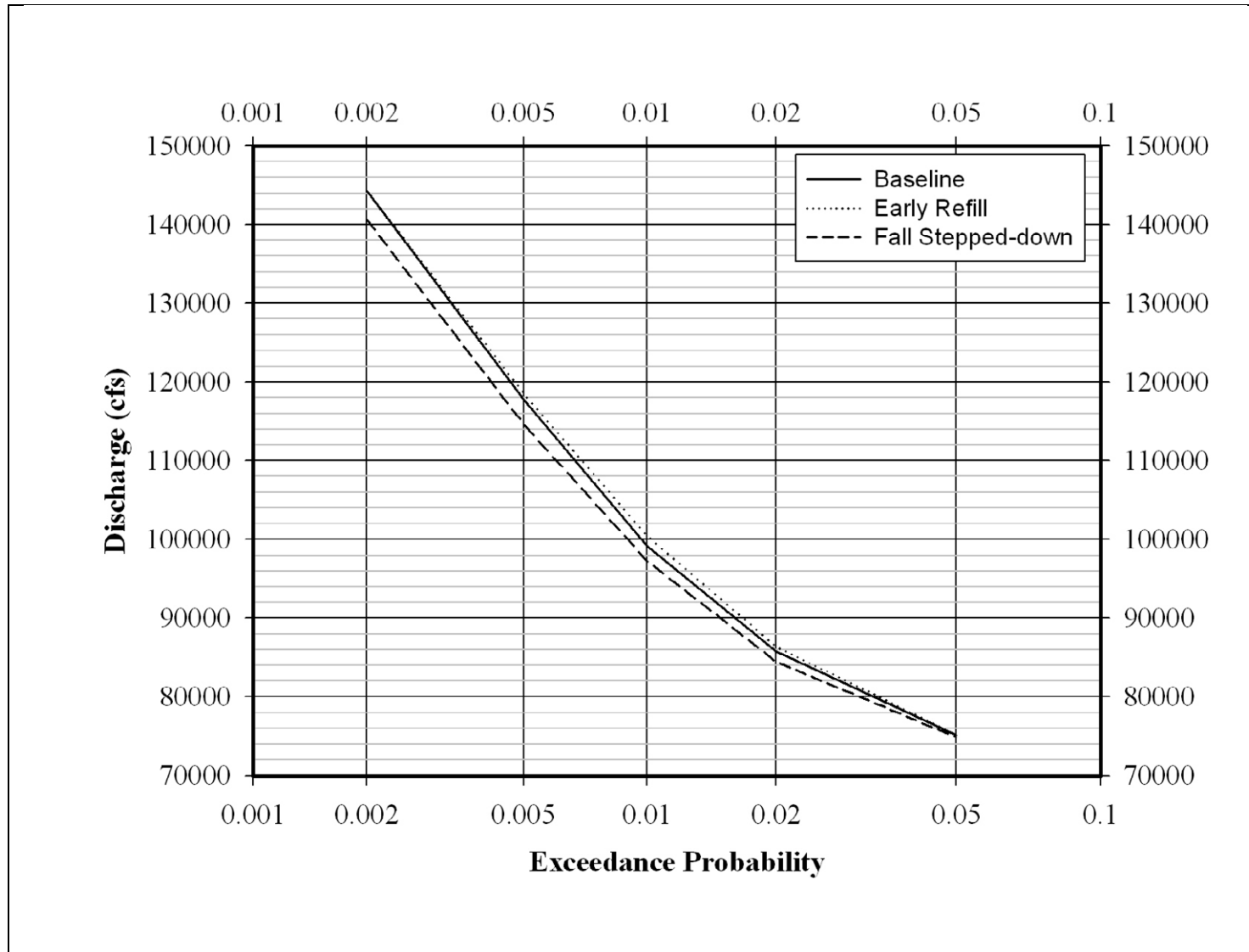


Figure I.22 Combined Flood Frequency Curves at Columbus Based on May 2003 Hydrograph Shapes

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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

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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.

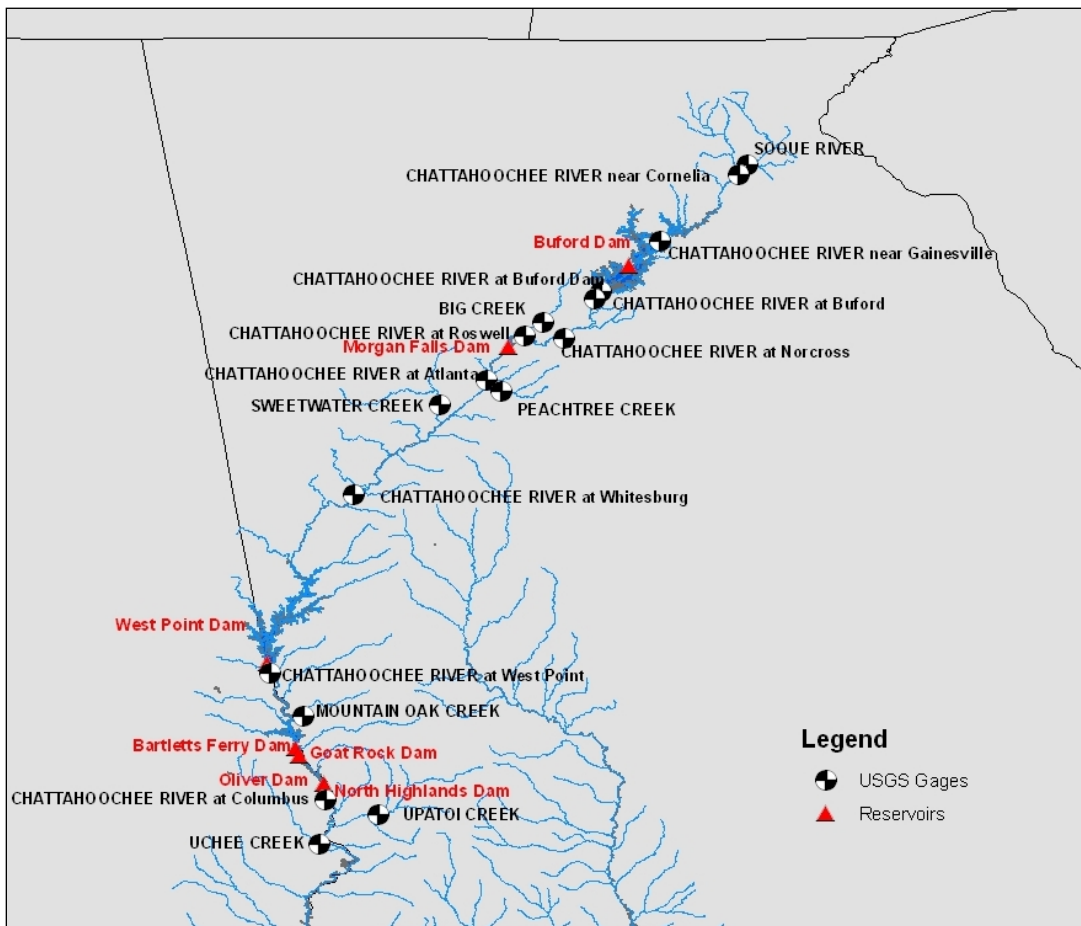


Figure J.01 ACF Basin above Columbus, GA.

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.

Appendix J – Sub-daily Flow Development

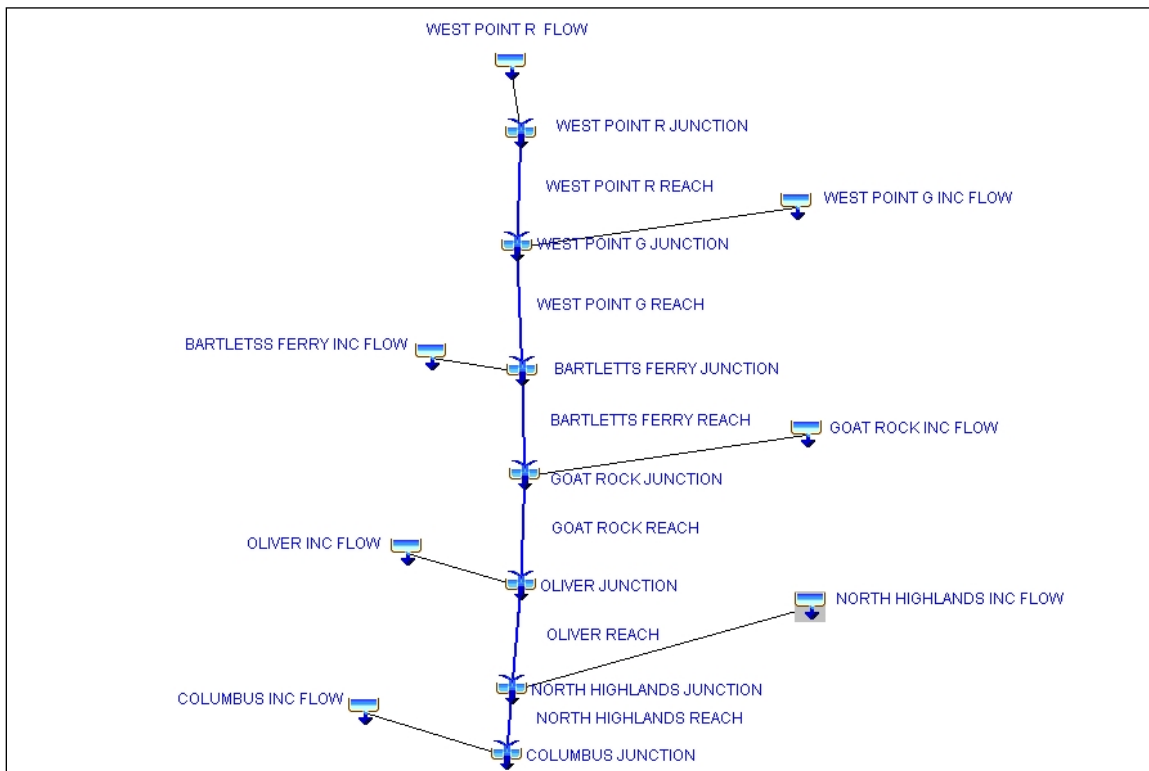


Figure J.02 ACF Model Node Schematic

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.

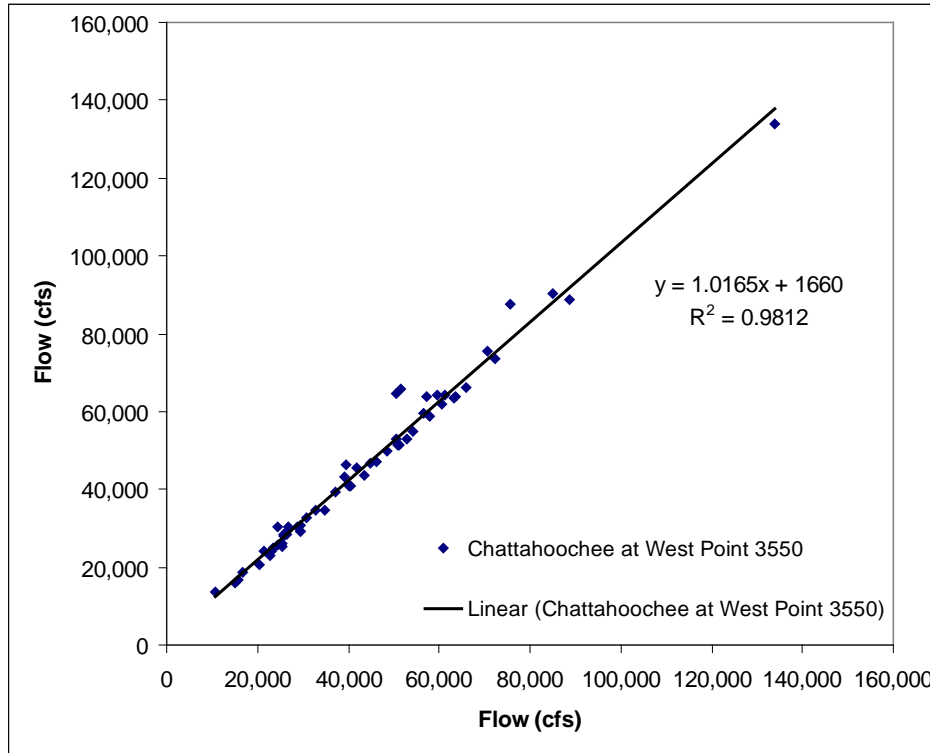


Figure J.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

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.

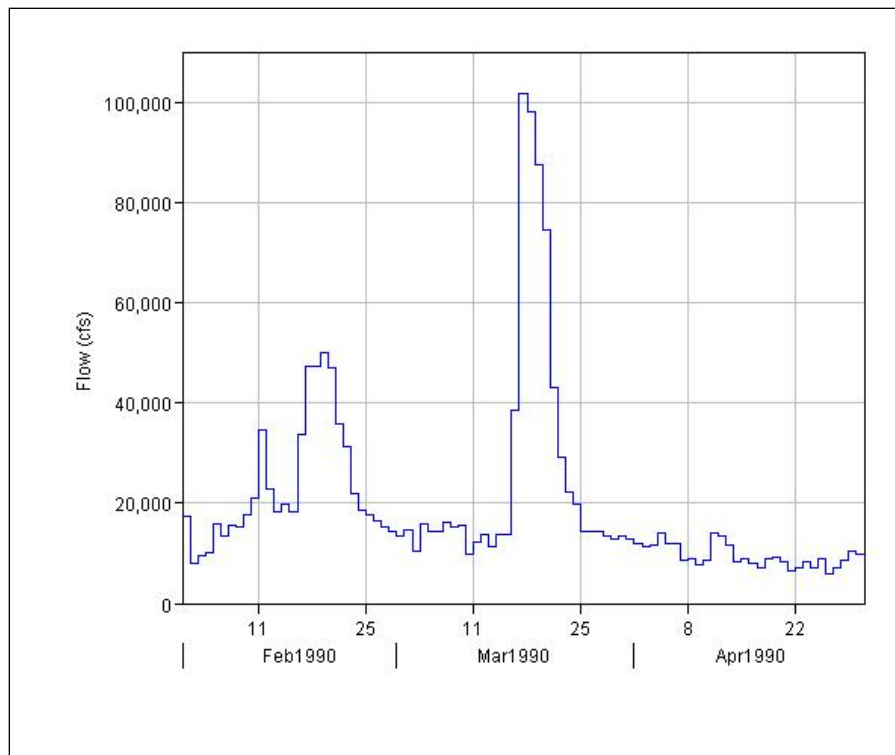


Figure J.04 March 1990 Flood Event at Columbus, GA

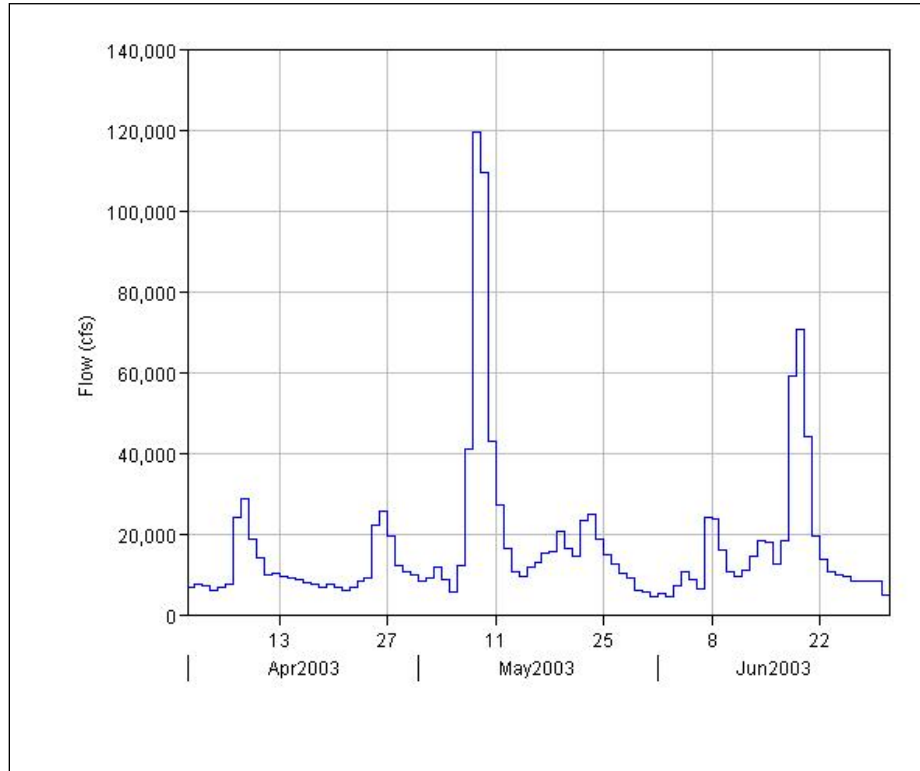


Figure J.05 May 2003 Flood Event at Columbus, GA

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.

Appendix J – Sub-daily Flow Development

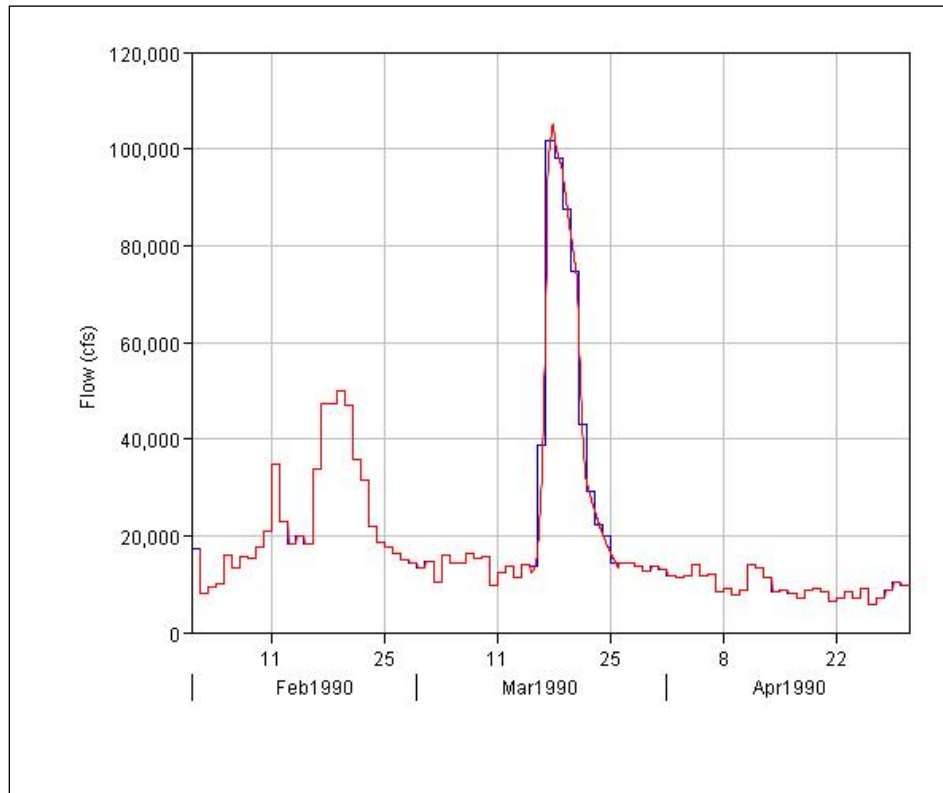


Figure J.06 March 1990 Daily vs. Hourly Flow Hydrographs at Columbus

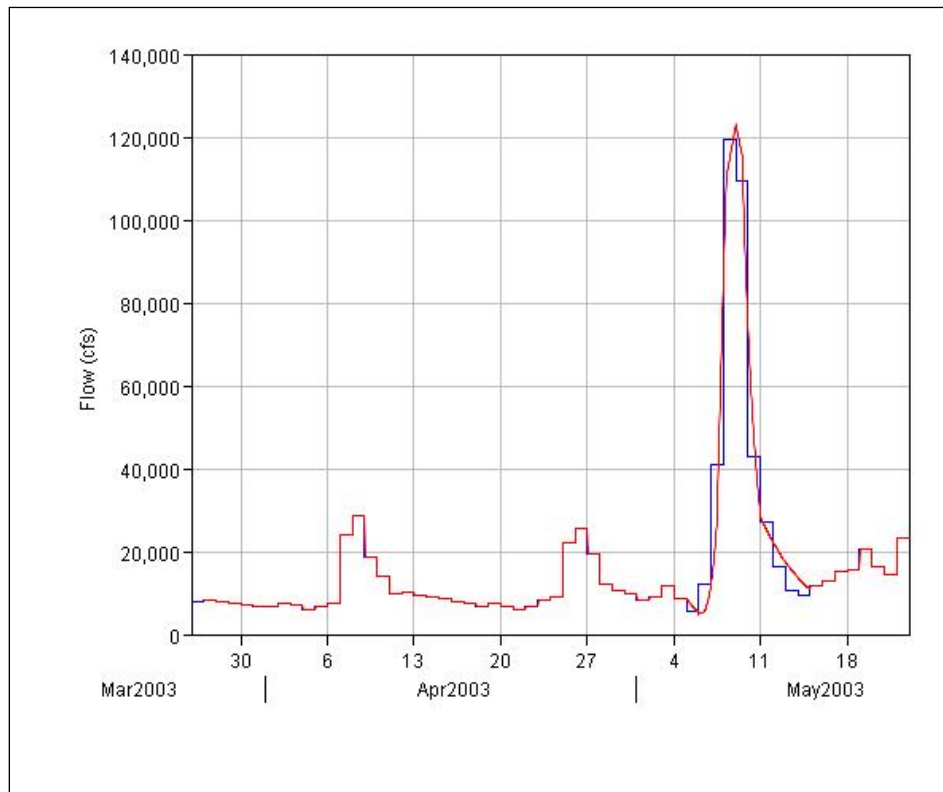


Figure J.07 May 2003 Daily vs. Hourly Flow Hydrographs at Columbus

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.

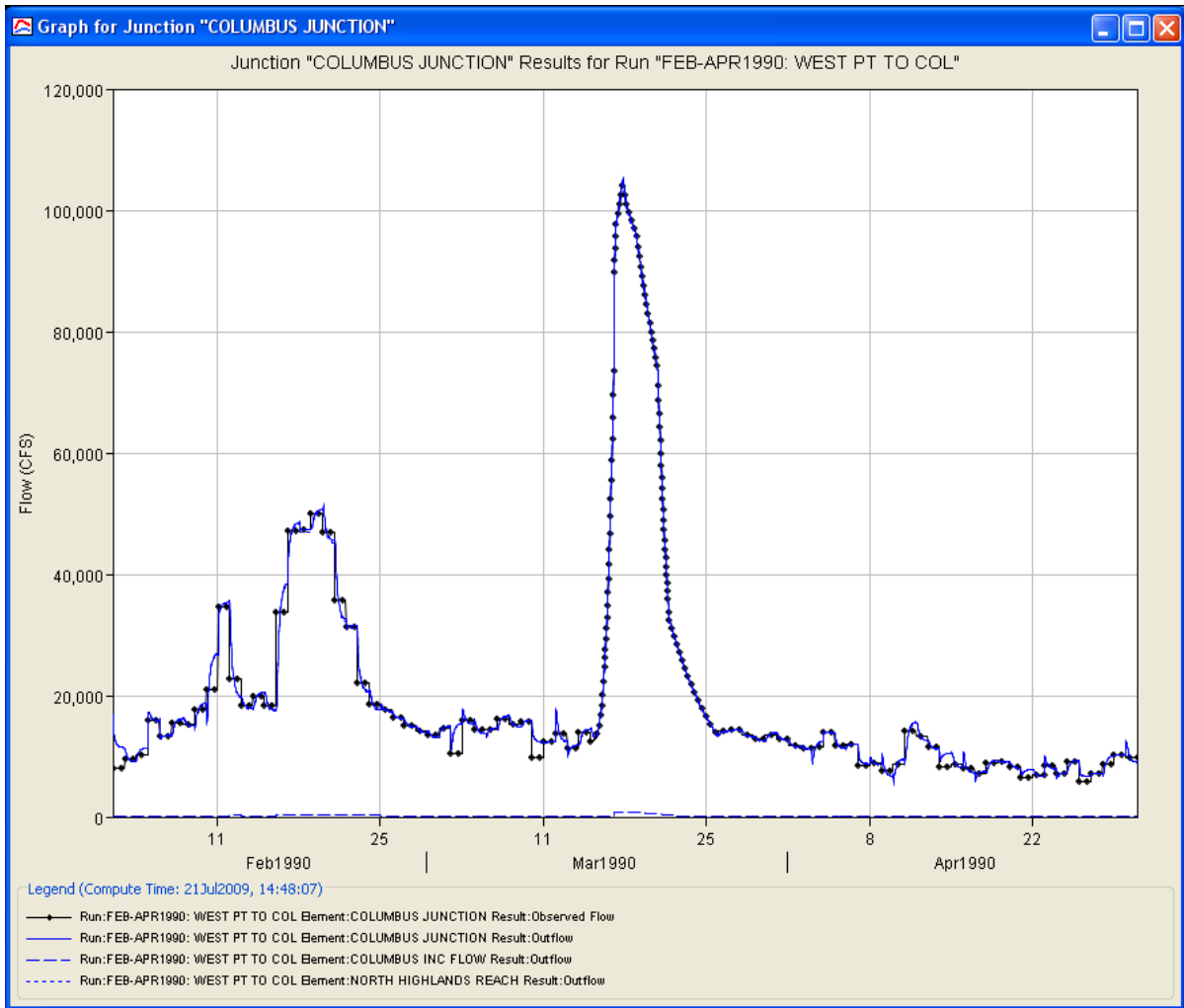


Figure J.08 HEC-HMS Model Results for the March 1990 Storm Event

Appendix J – Sub-daily Flow Development

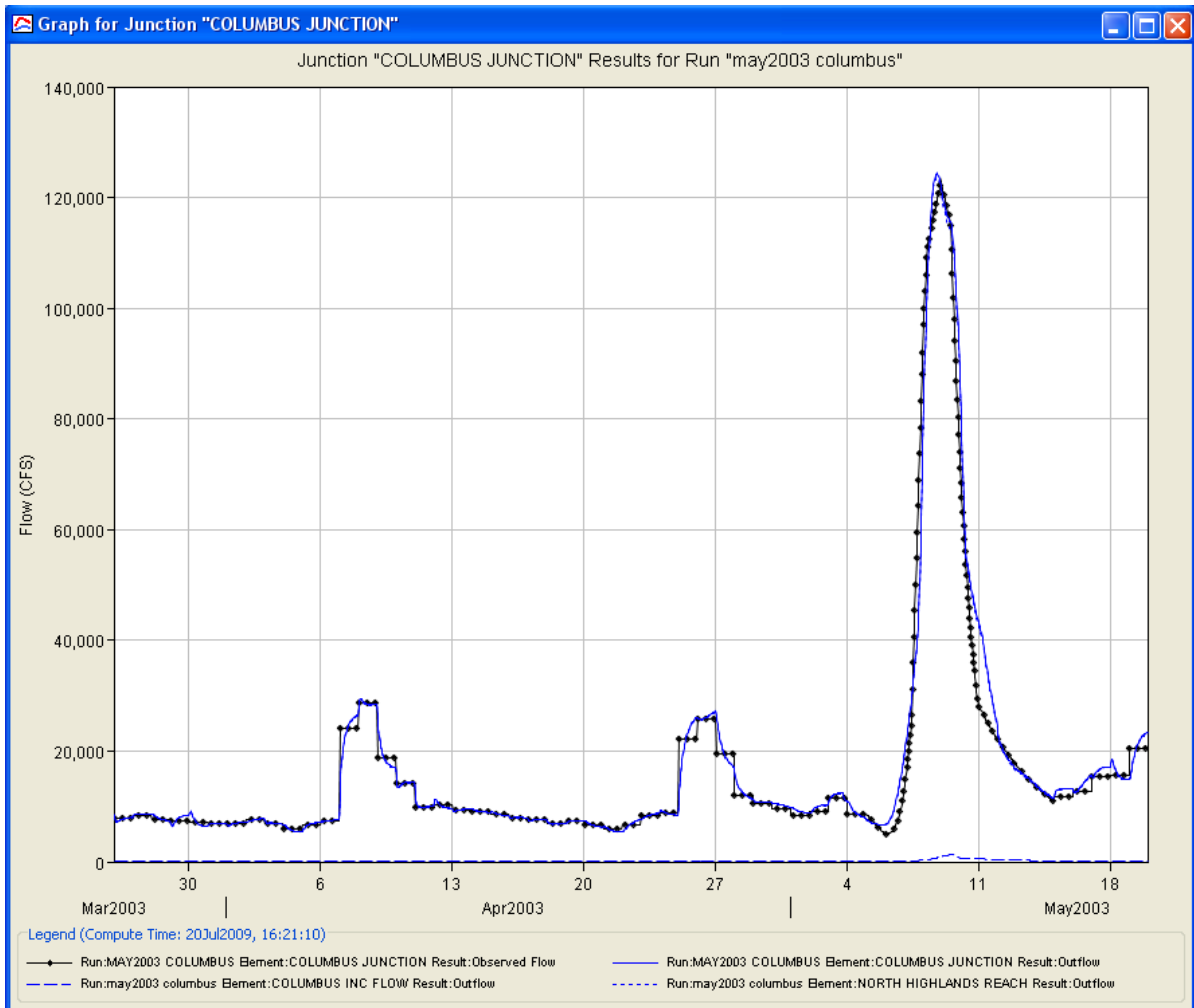


Figure J.09 HEC-HMS Model Results for the May 2003 Storm Event

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

Appendix J – Sub-daily Flow Development

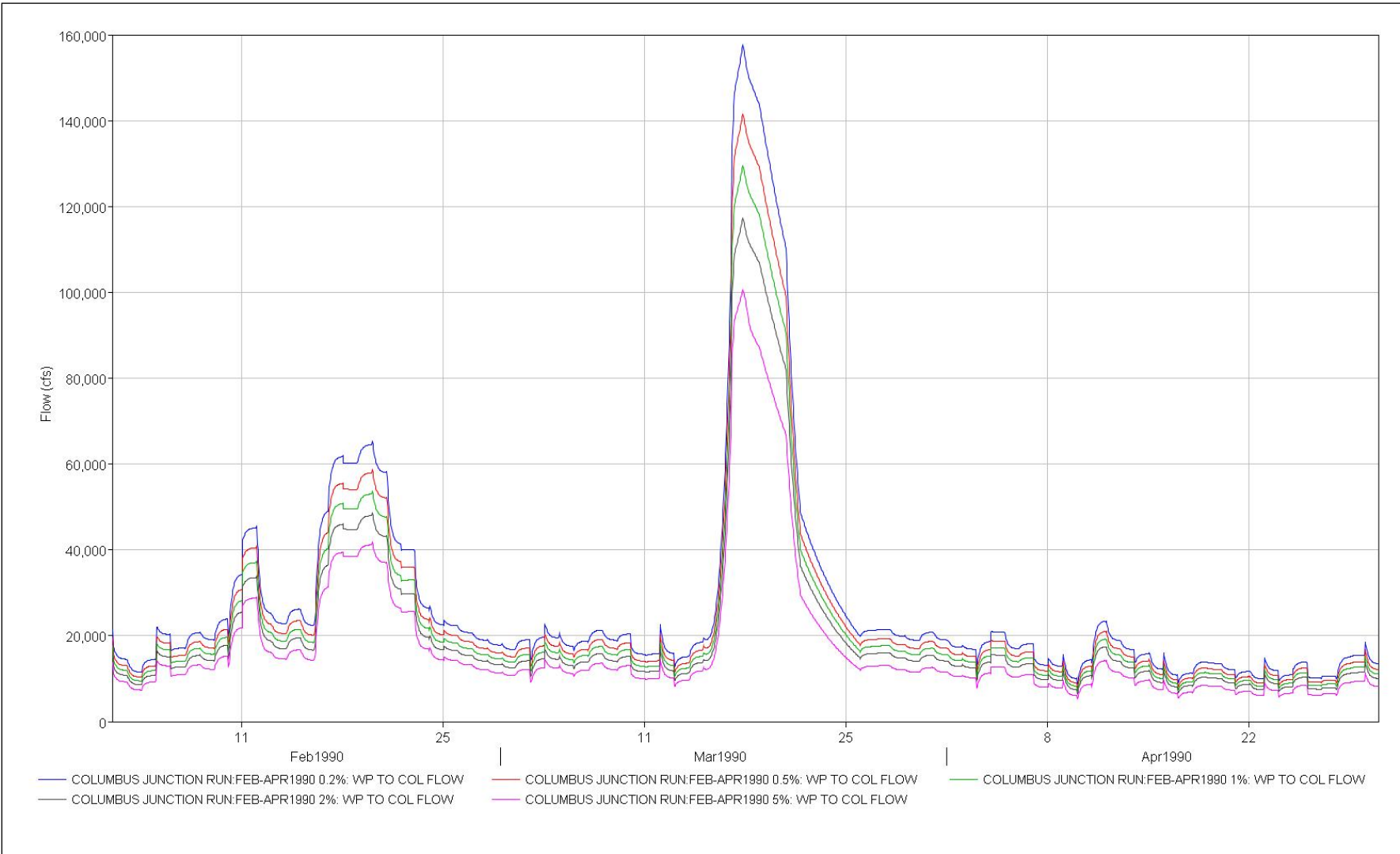


Figure J.10 HEC-HMS Hourly Unimpaired Hypothetical Hydrographs for the March 1990 Event

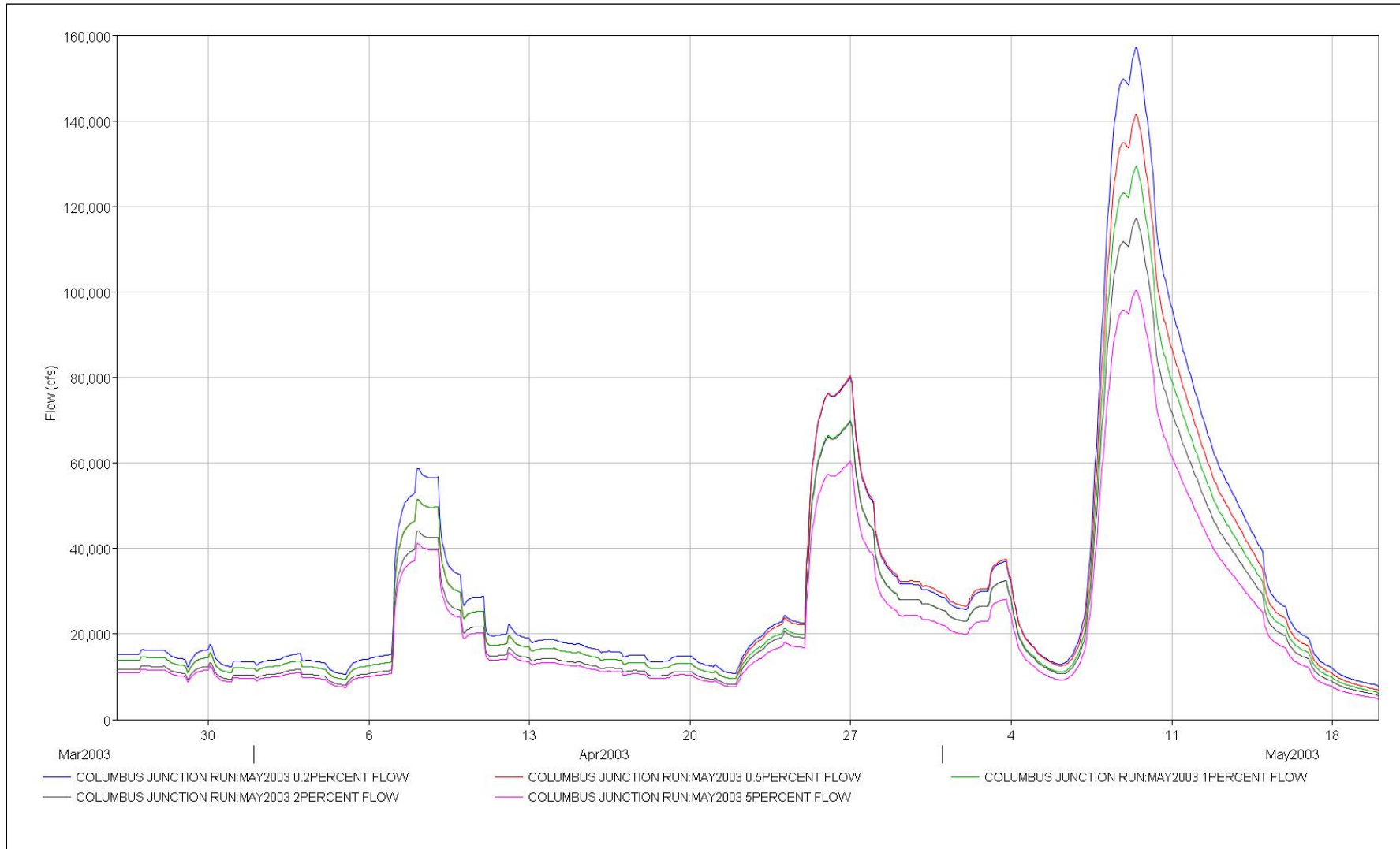


Figure J.11 HEC-HMS Hourly Unimpaired Hypothetical Hydrographs for the May 2003 Event

Appendix J – Sub-daily Flow Development

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.

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

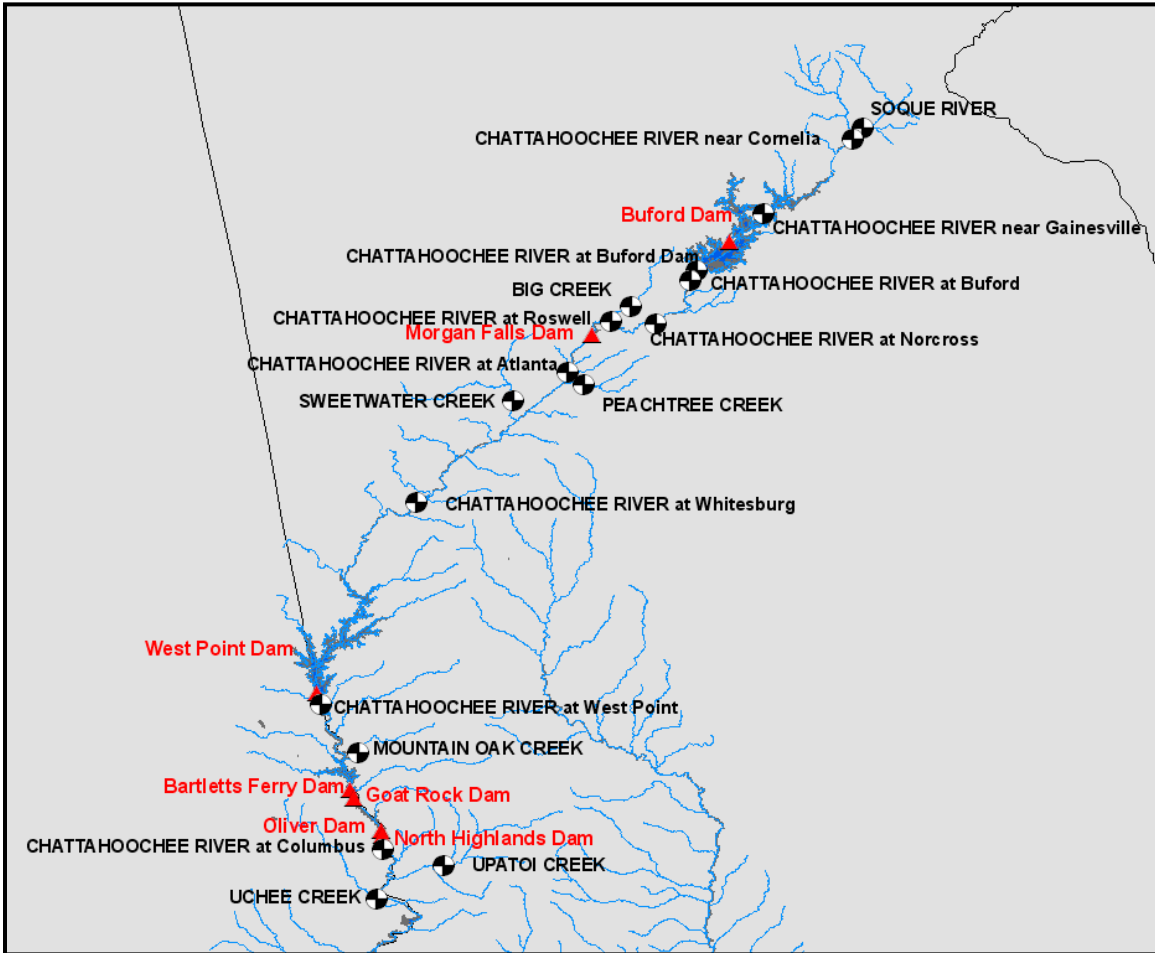


Figure J-A.01 Chattahoochee River - Columbus Analysis

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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	

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

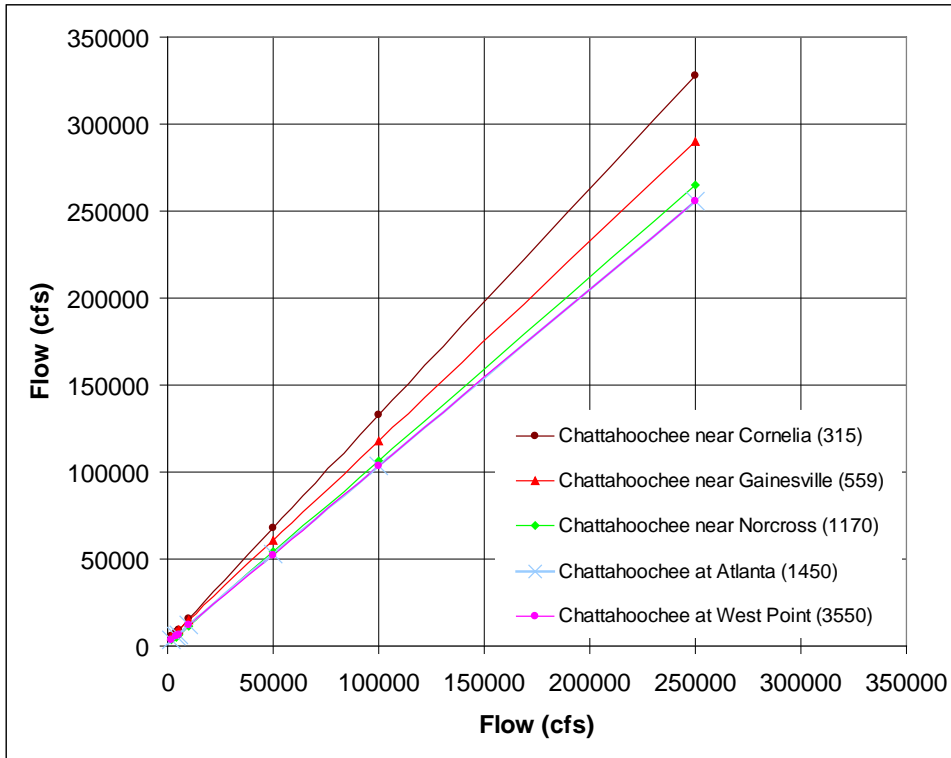


Figure J-A.02 Instantaneous Peak Flow vs. Daily Average Flow Relationship for Stream Gages on the Chattahoochee River

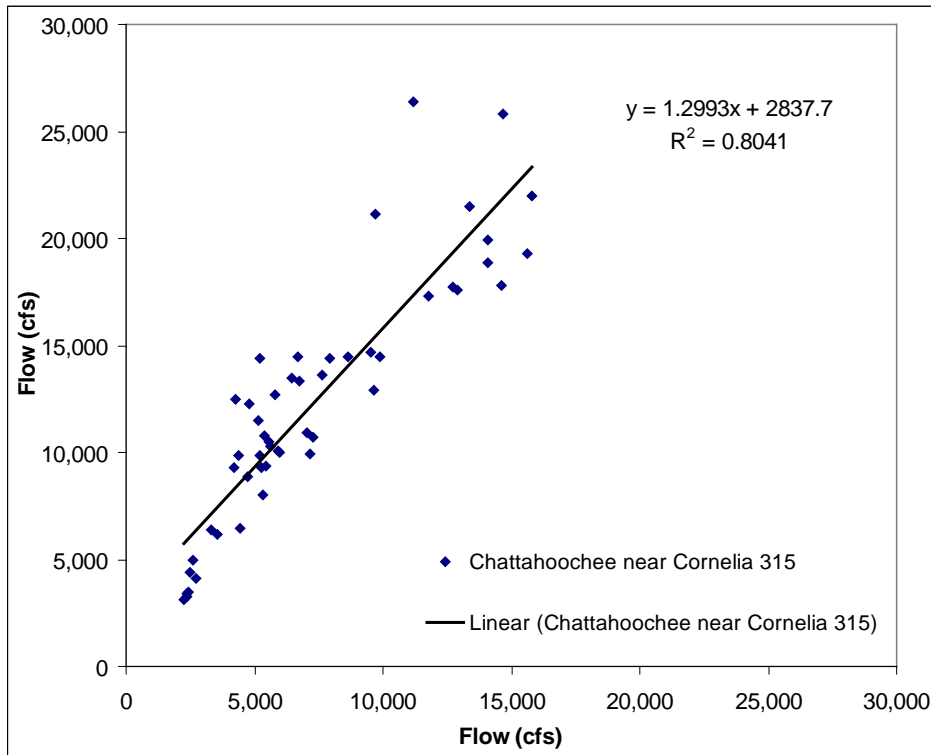


Figure J-A.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Cornelia Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

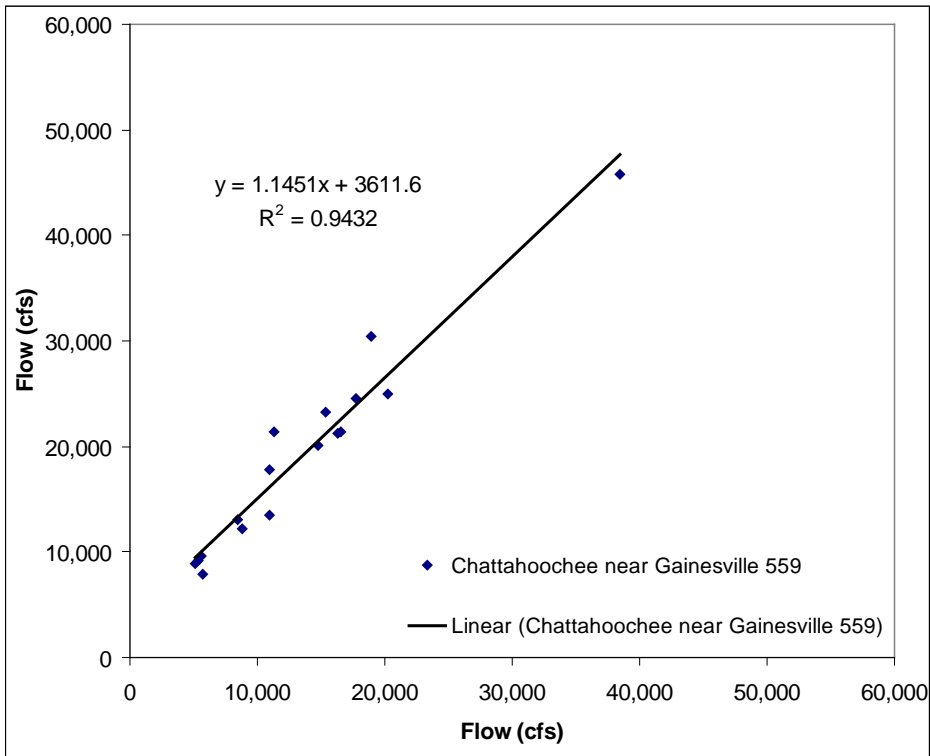


Figure J-A.04 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Gainesville Gage

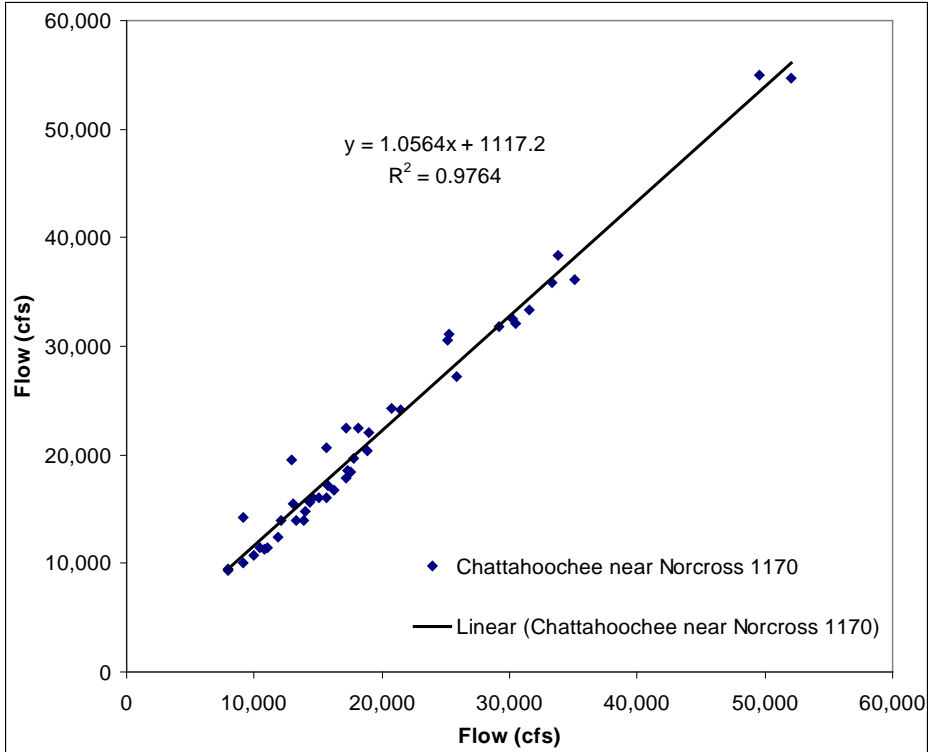


Figure J-A.05 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Norcross Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

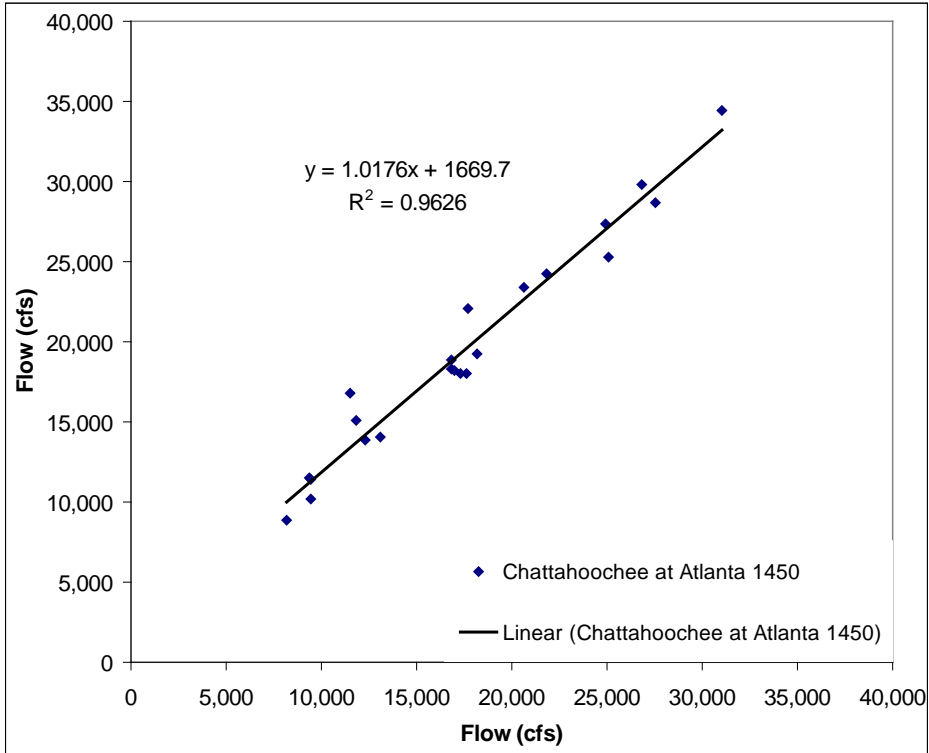


Figure J-A.06 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Atlanta Gage

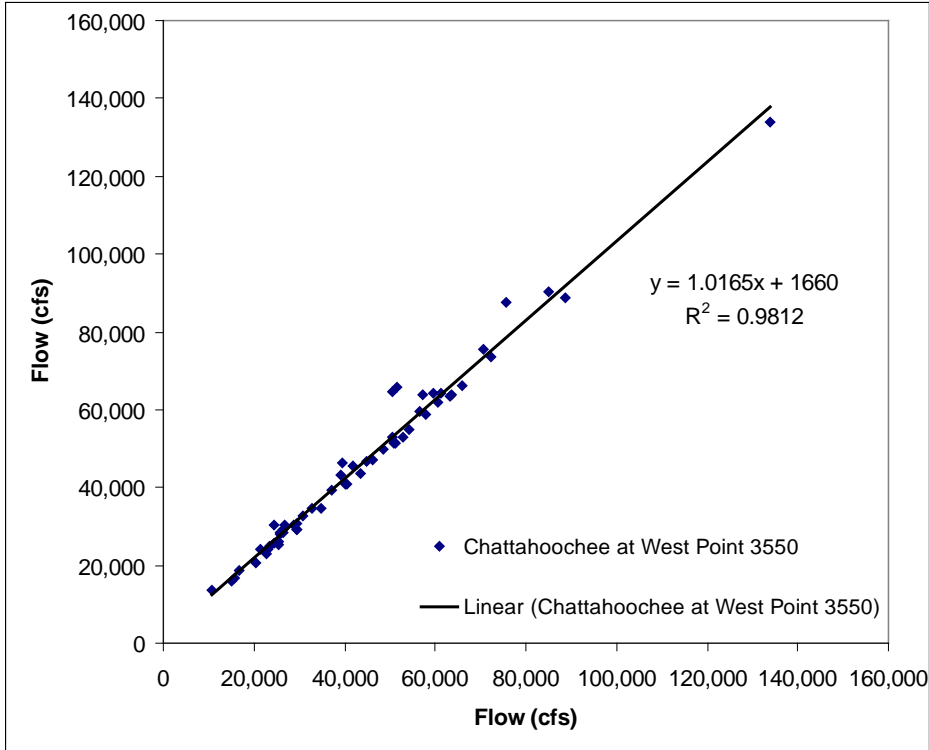


Figure J-A.07 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

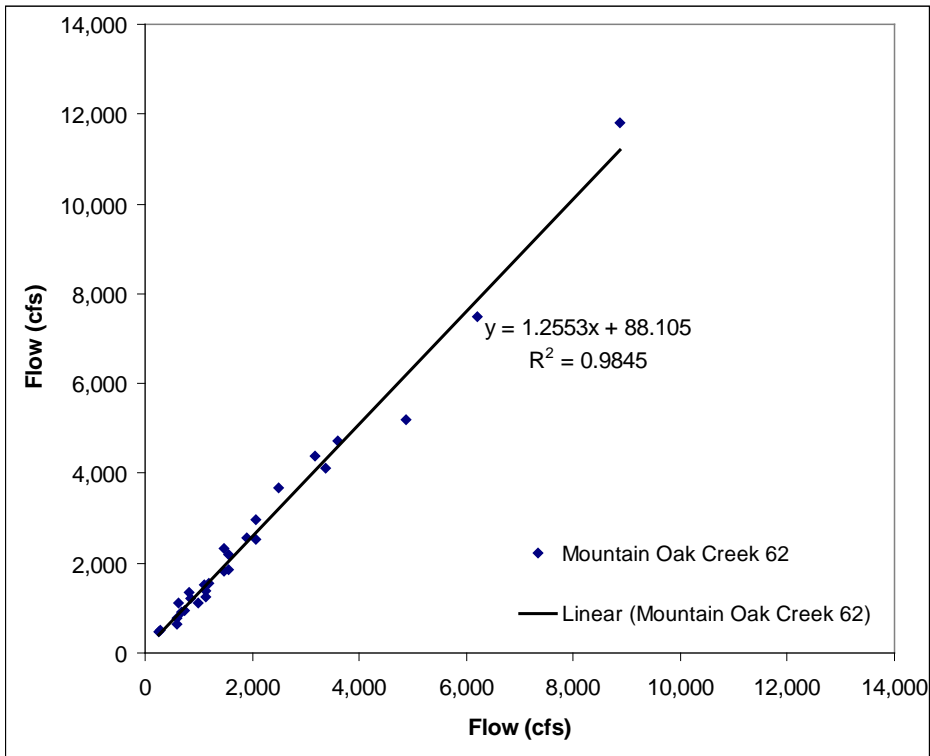


Figure J-A.08 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Mountain Oak Creek Gage

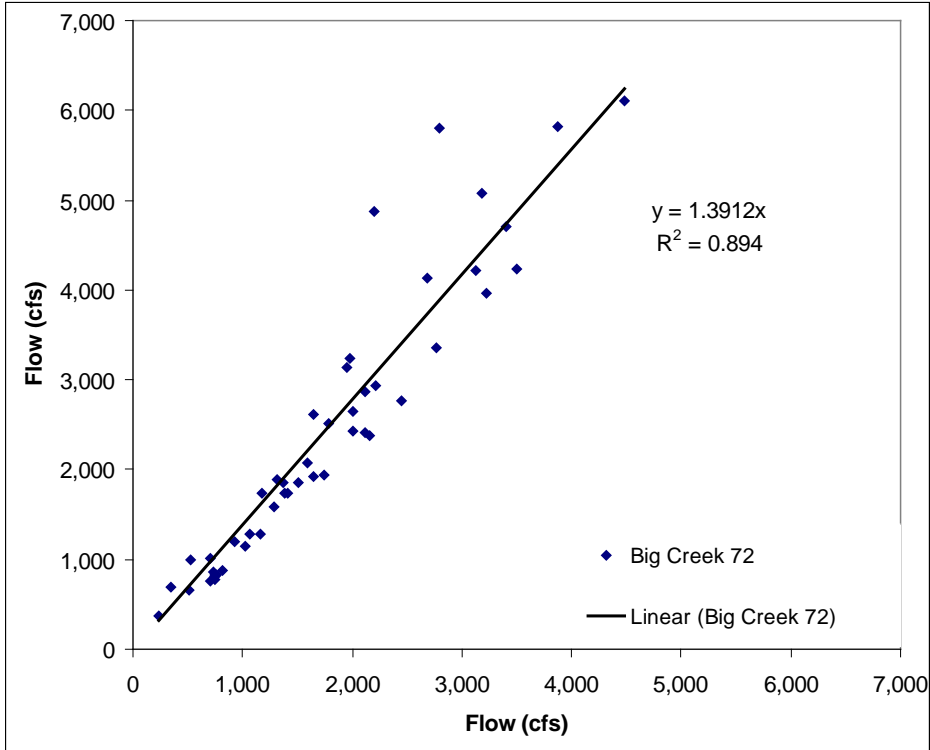


Figure J-A.09 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Big Creek Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

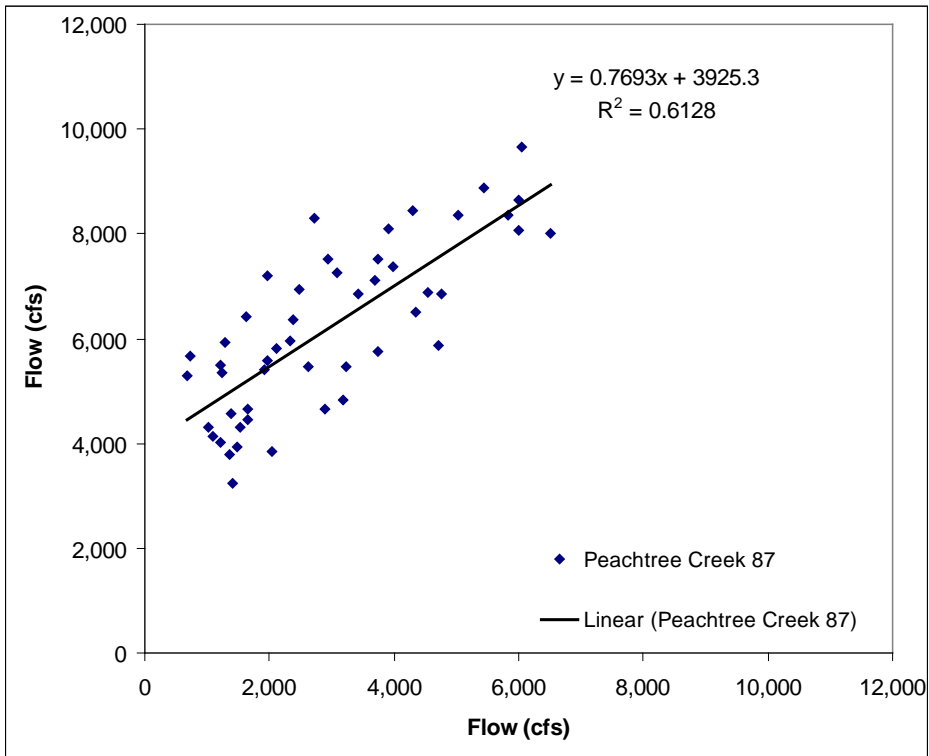


Figure J-A.10 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Peachtree Gage

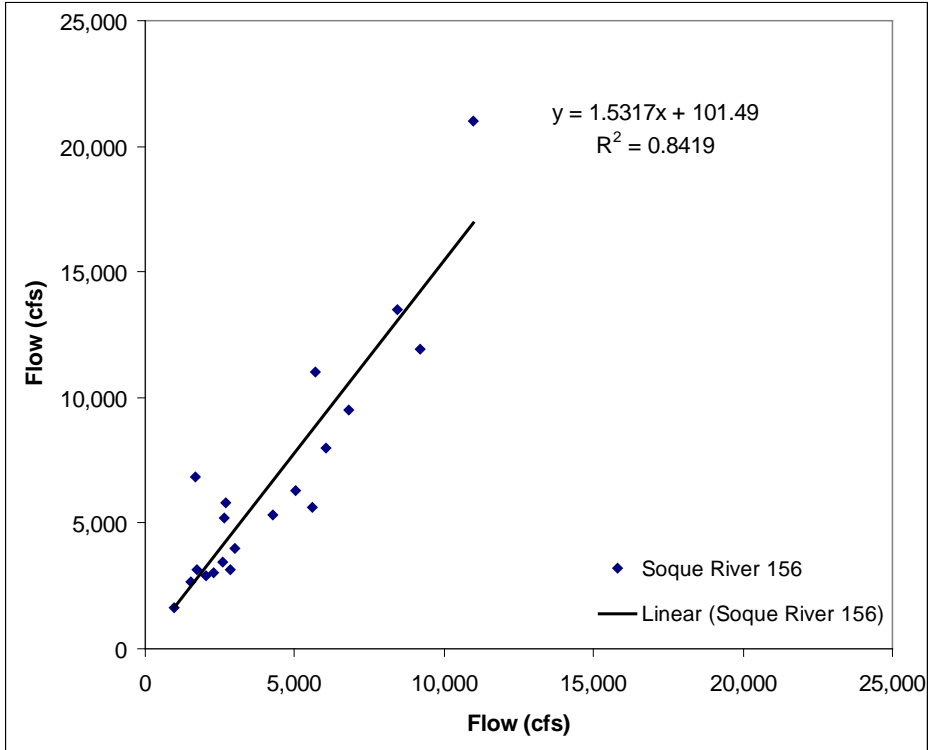


Figure J-A.11 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Soque River Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

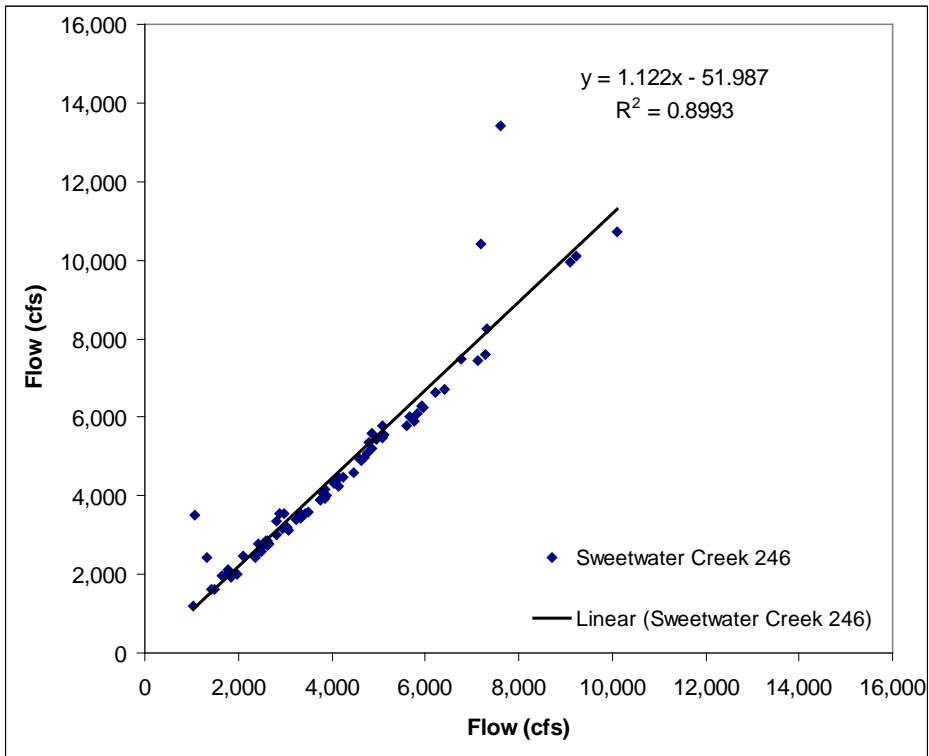


Figure J-A.12 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Sweetwater Creek Gage

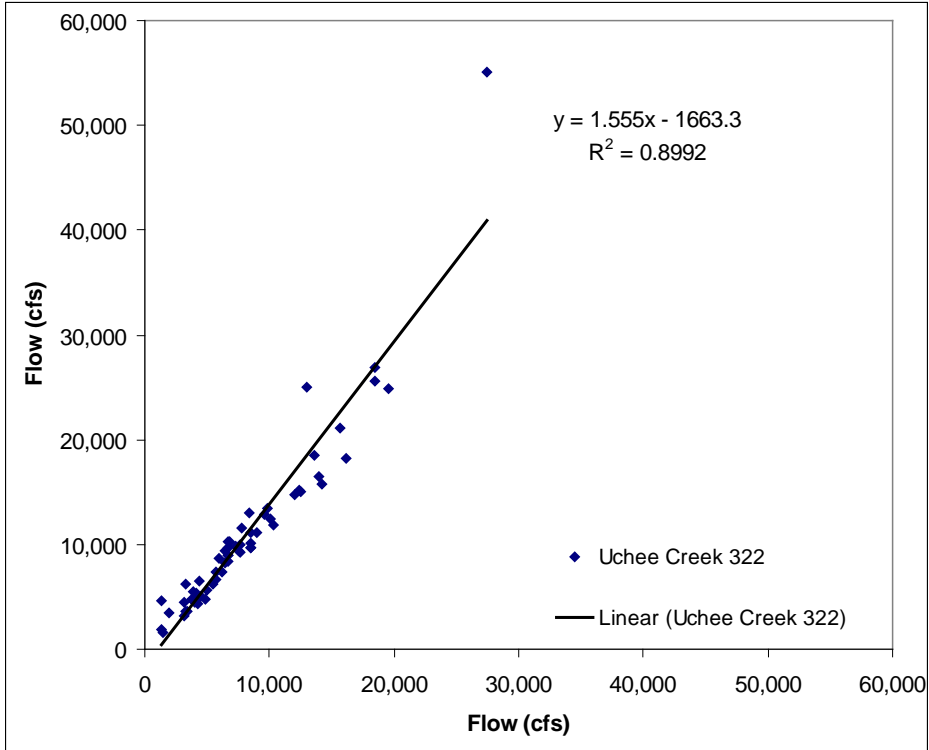


Figure J-A.13 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Uchee Creek Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

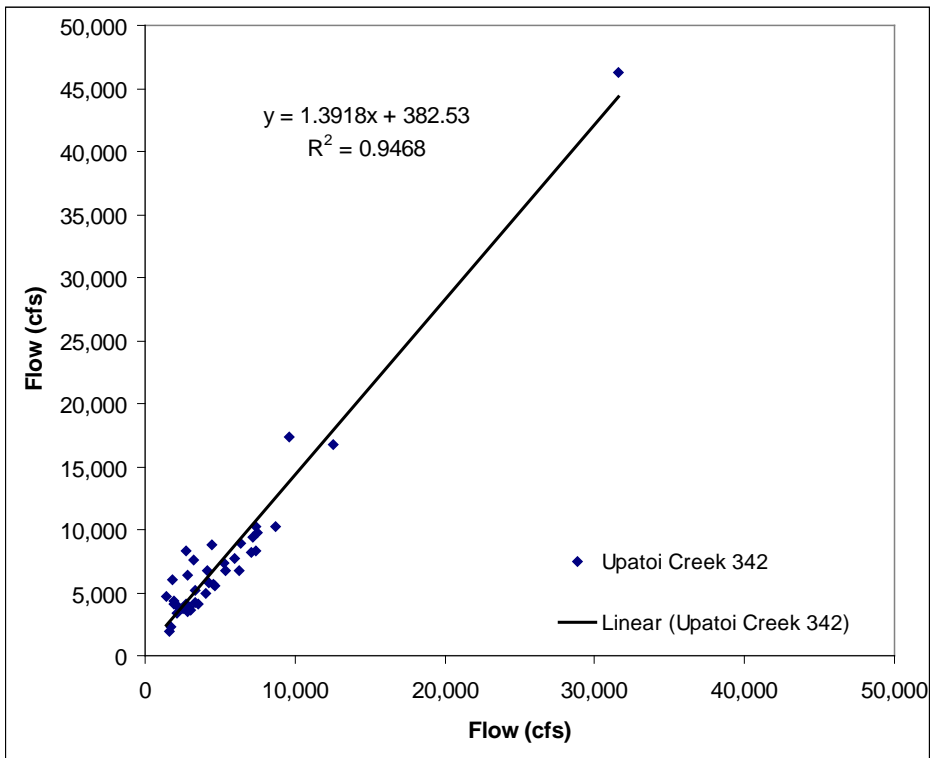


Figure J-A.14 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Upatoi Creek Gage

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

Table J-A-12. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Sweetwater Creek Gage (246)

Date	Daily	Instantaneous
	Average Flow	Peak Flow
	cfs	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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

**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

Appendix J-A: Development of Instantaneous vs. Peak Flow Relationships

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: 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.

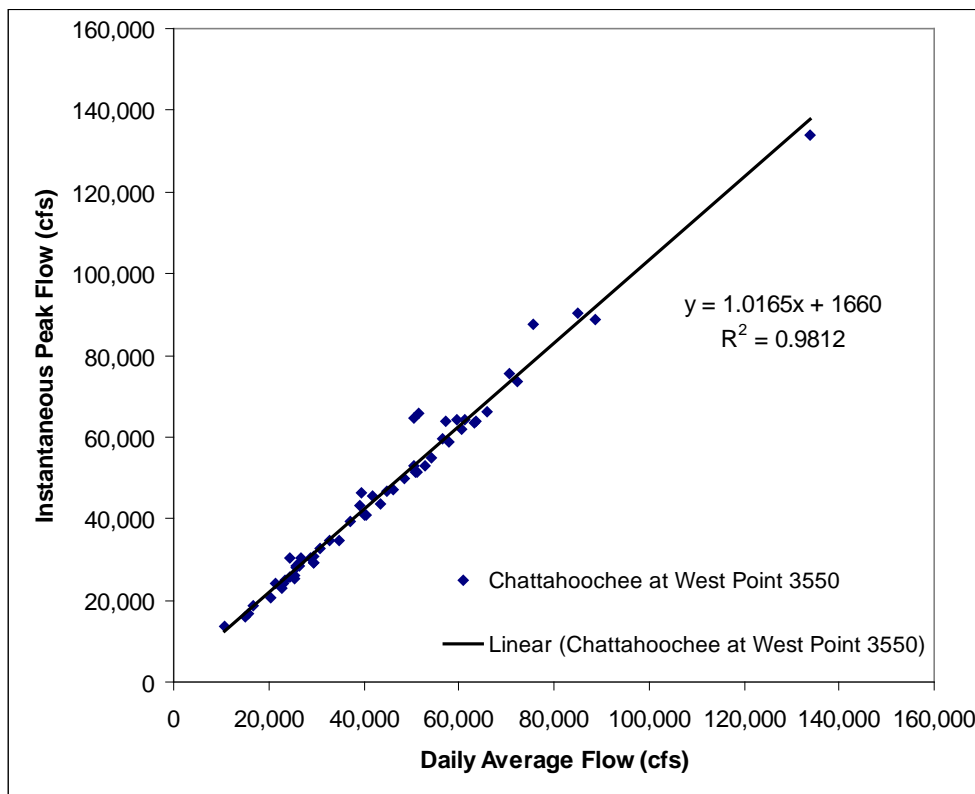


Figure J-B.01 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the West Point Gage

Appendix J-B: Development of Unimpaired Peak Flow Frequencies at Columbus

Table J-B-01. 1-Day and Instantaneous Peak Flows at Columbus

Date	1-Day Annual Maximum	Instantaneous Annual Peak (Compute)
	CFS	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 ...

Appendix J-B: Development of Unimpaired Peak Flow Frequencies at Columbus

Table J-B-01. 1-Day and Instantaneous Peak Flows at Columbus (Continued)

Date	1-Day Annual Maximum	Instantaneous Annual Peak (Compute)
	CFS	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

Appendix J-B: Development of Unimpaired Peak Flow Frequencies at Columbus

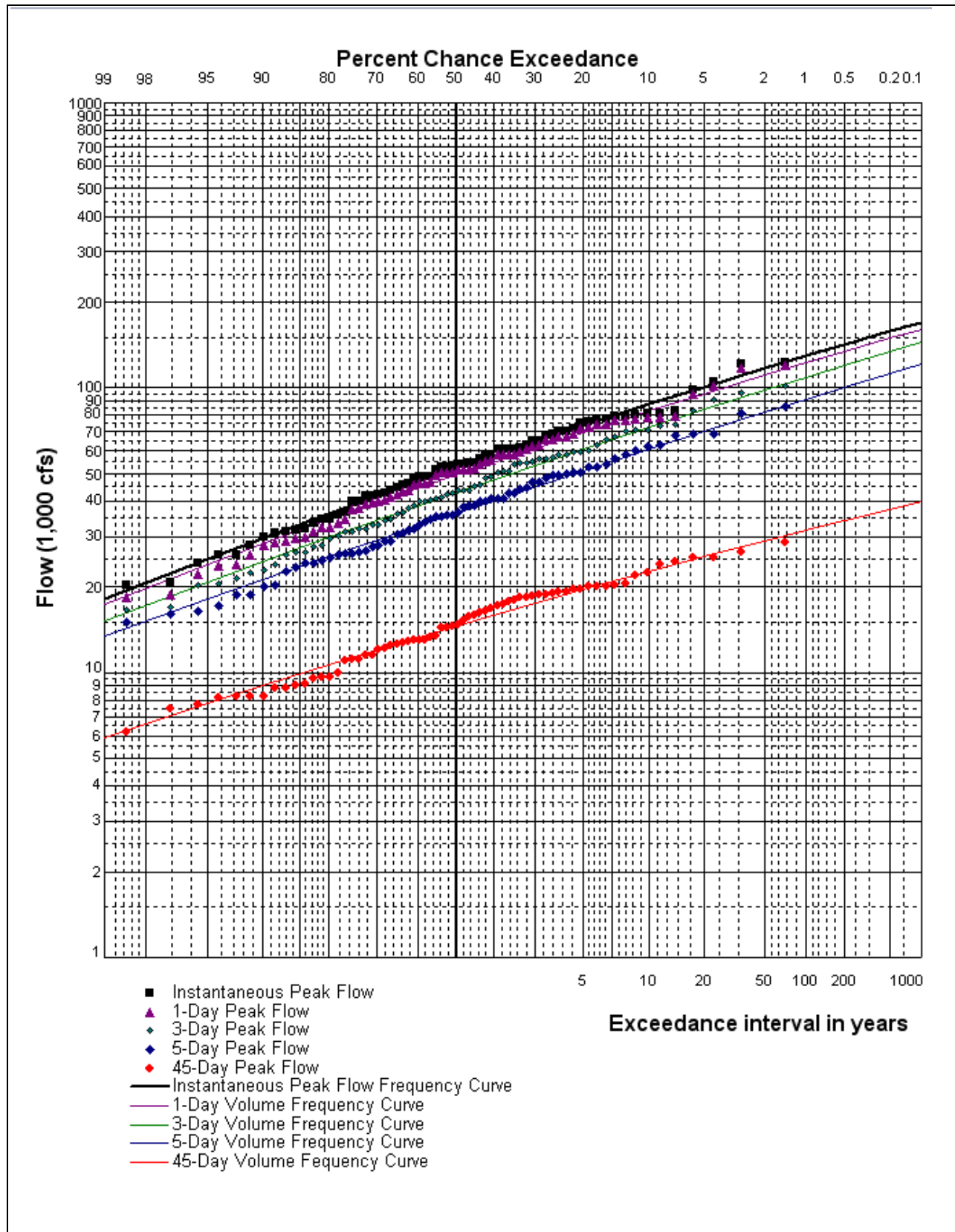


Figure J-B.02 Peak, 1-Day, 3-Day, 5-Day, and 45-Day Frequency Curves at Columbus

Appendix J-C

Conversion of Daily Average Unimpaired Data to Hourly Values

Appendix J-C: Conversion of Daily 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.

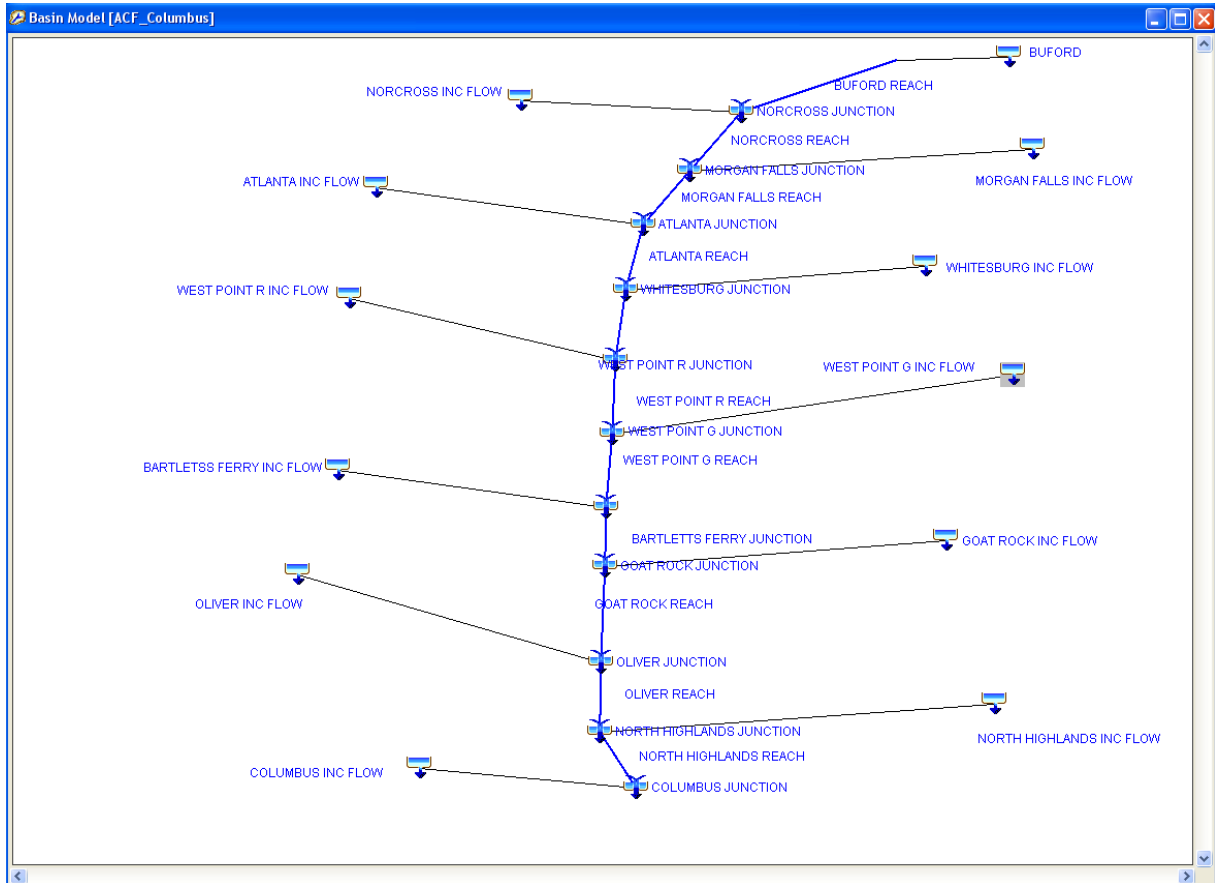


Figure J-C.01 ACF Schematic from Buford Dam to Columbus

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.

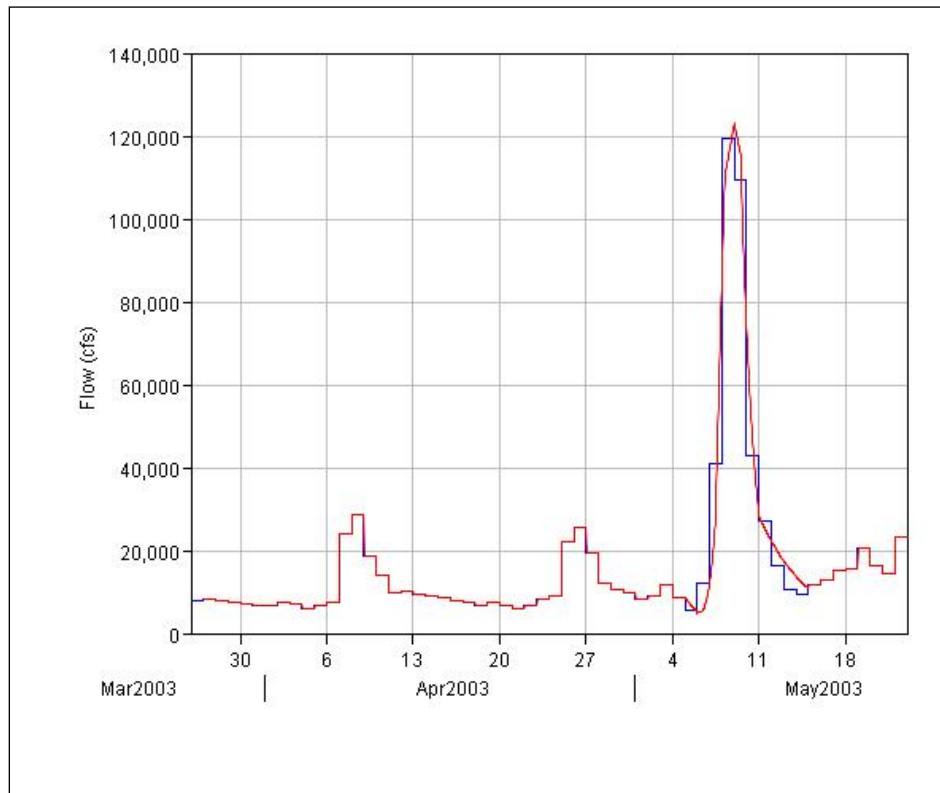


Figure J-C.02 May 2003 Daily vs. Hourly Storm Hydrographs at Columbus

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.

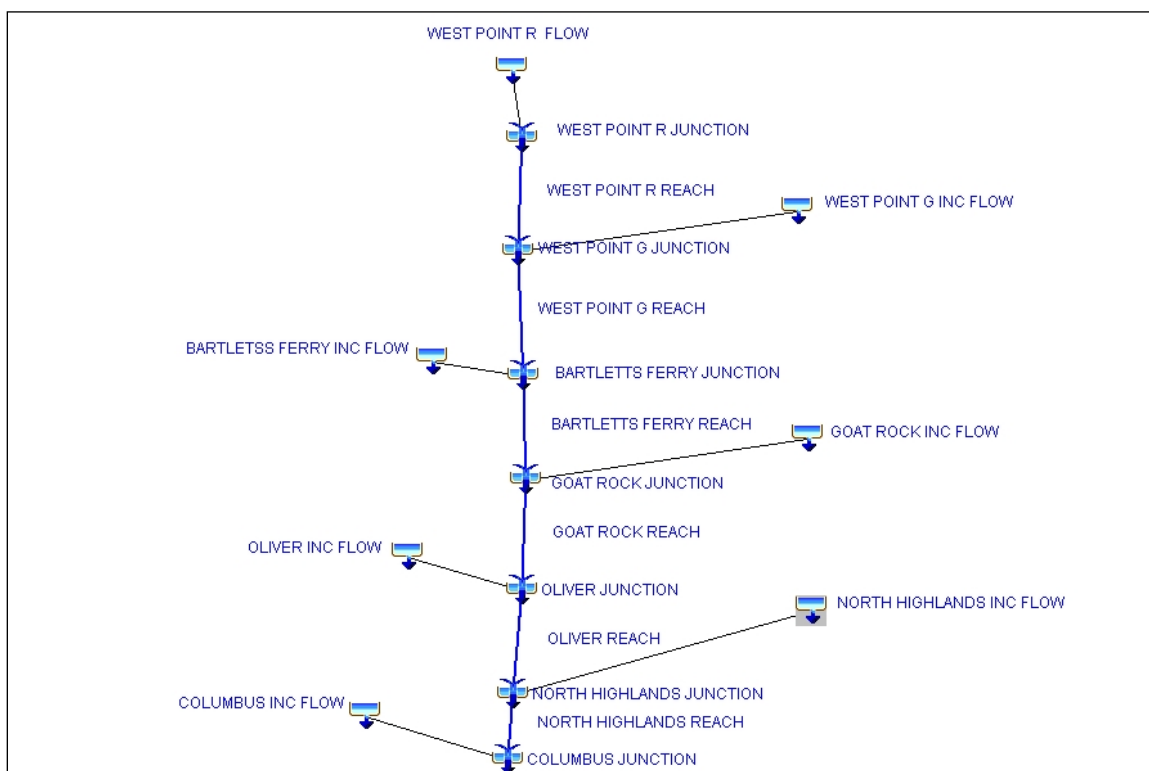


Figure J-C.03 ACF Model Node Schematic

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.

Appendix J-C: Conversion of Daily Data to Hourly Values

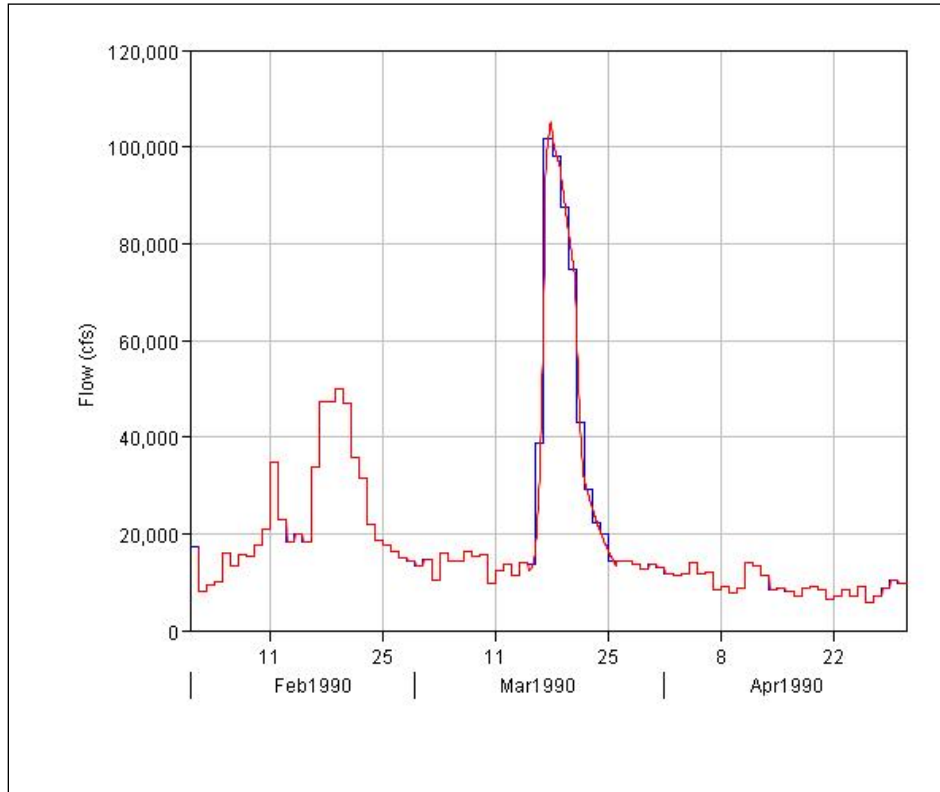


Figure J-C.04 March 1990 Daily vs. Hourly Storm Hydrographs at Columbus

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.

Appendix J-C: Conversion of Daily Data to Hourly Values

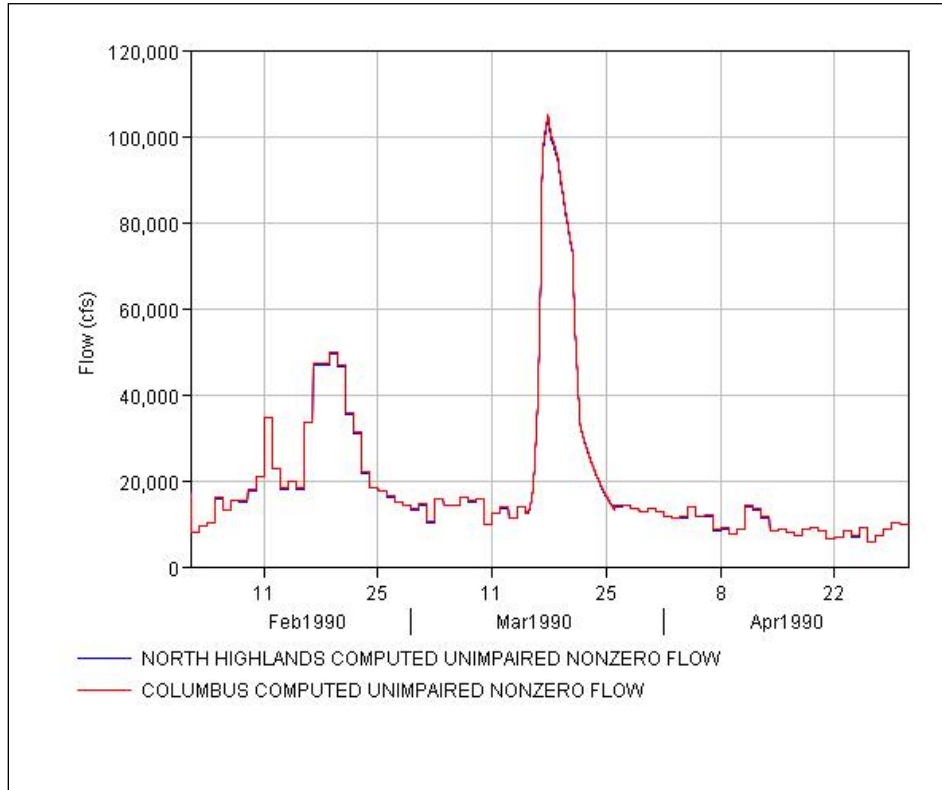


Figure J-C.05 Hourly flow at Columbus and Routed Hourly Flow from North Highlands for March 1990 Event

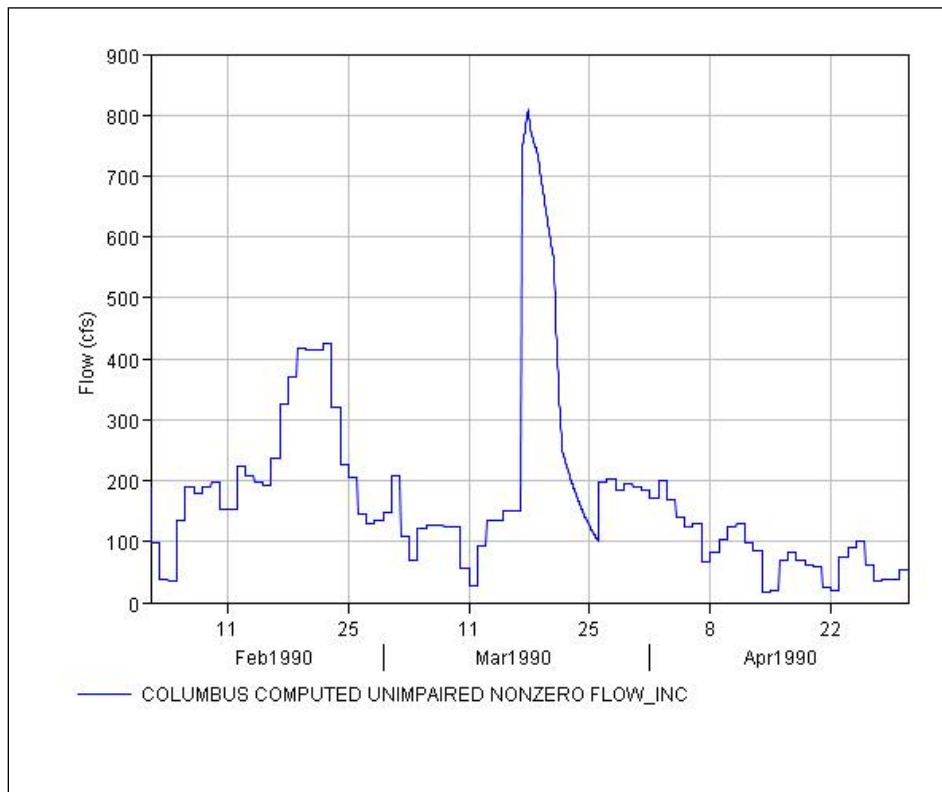


Figure J-C.06 Hourly Local Flow at Columbus for March 1990 Event

Appendix J-D

Development and Calibration of HEC-HMS Model

Appendix J-D: Development and Calibration of HEC-HMS Model

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.

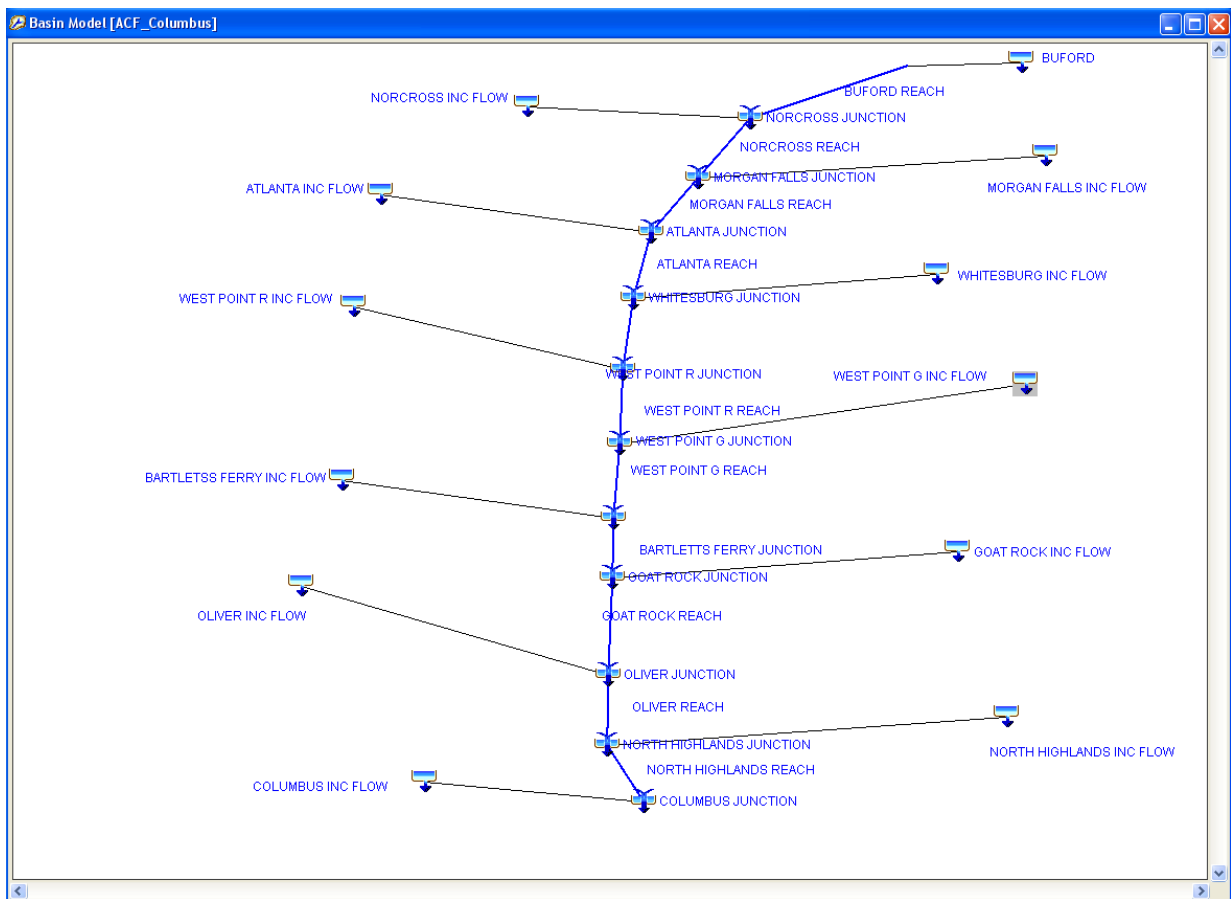


Figure J-D.01 Schematic of HEC-HMS Model from Buford Dam to Columbus Developed by HEC

Appendix J-D: Development and Calibration of HEC-HMS Model

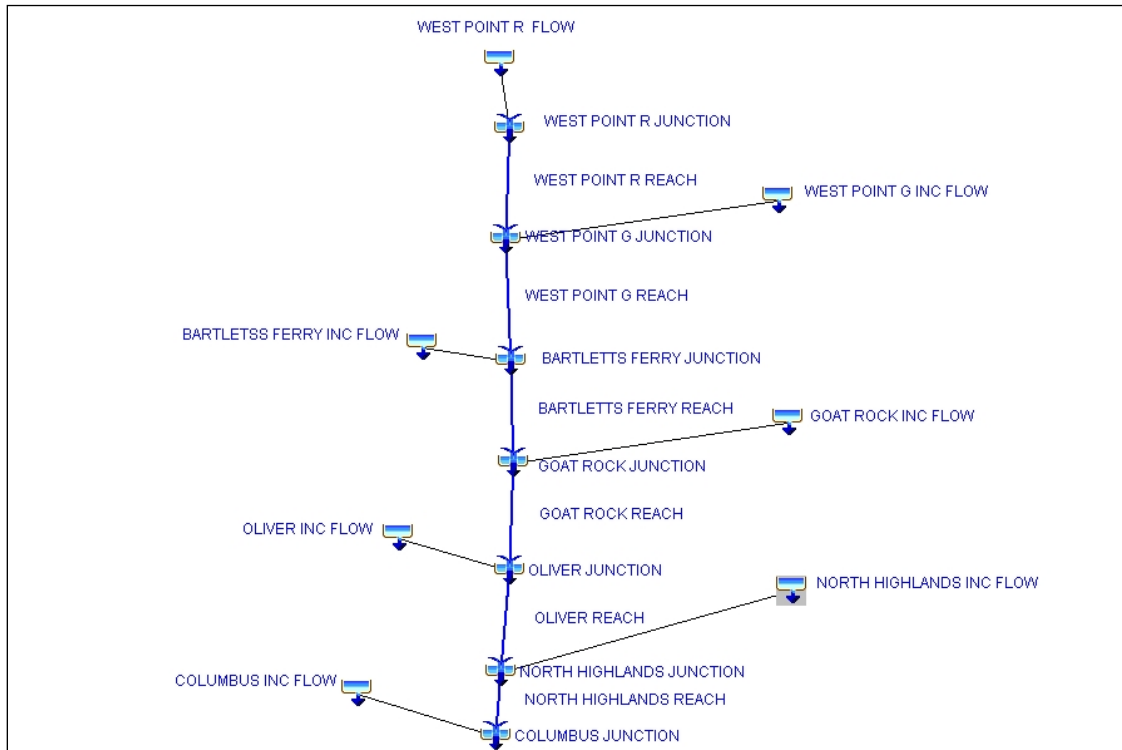


Figure J-D.02 Schematic of HEC-HMS Model from West Point R to Columbus Developed by the USACE Mobile District

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		

Appendix J-D: Development and Calibration of HEC-HMS Model

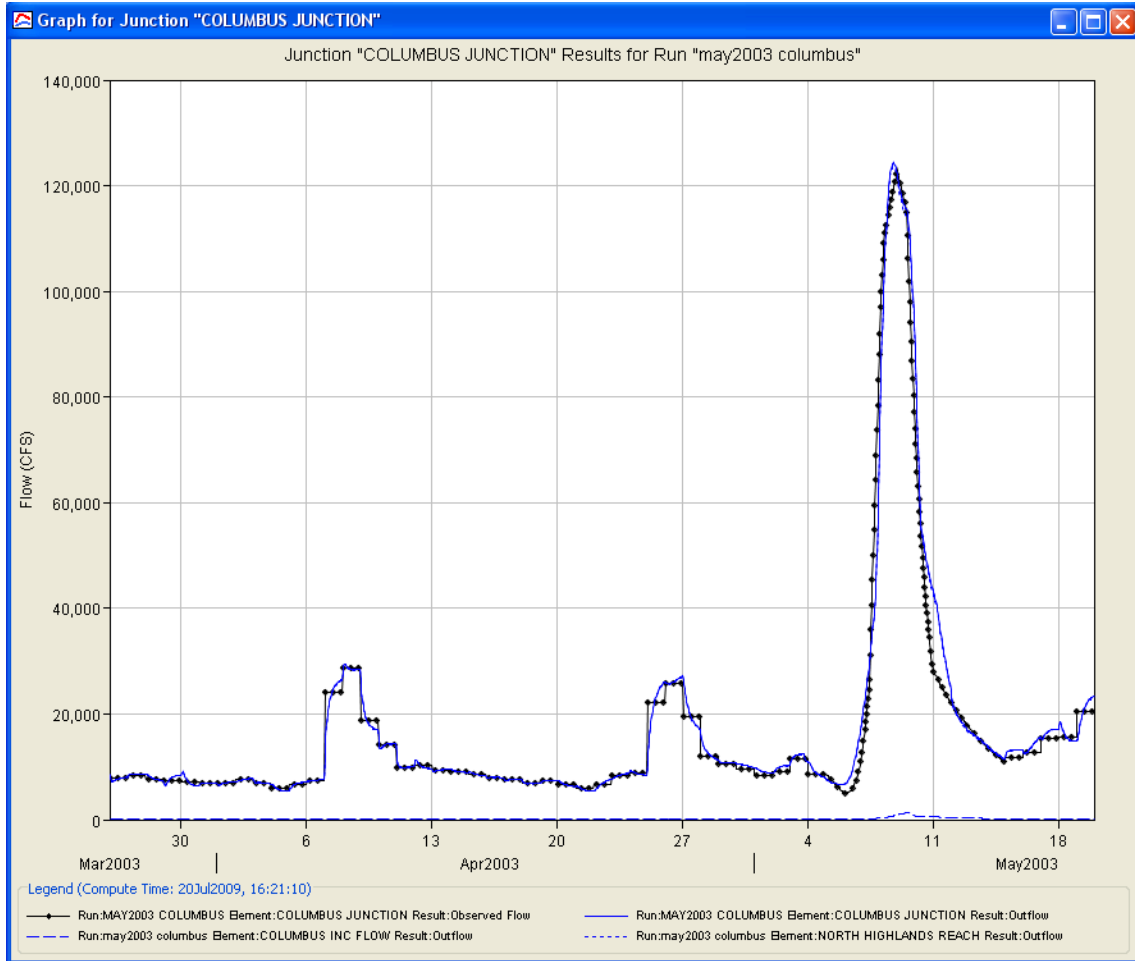


Figure J-D.03 HEC-HMS Model Results at Columbus for the May 2003 Event

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.

Appendix J-D: Development and Calibration of HEC-HMS Model

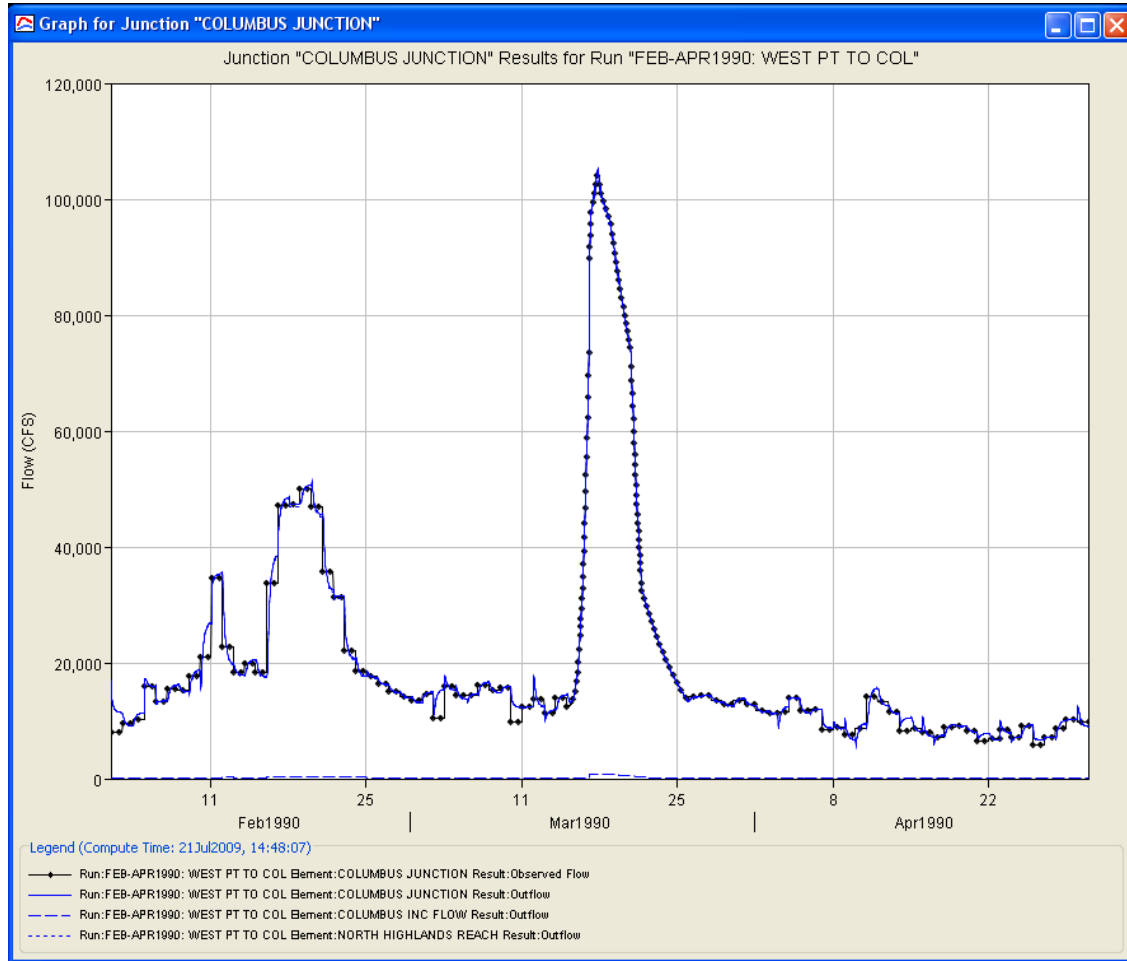


Figure J-D.04 HEC-HMS Model Results at Columbus for the March 1990 Event

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

Prepared for:
US Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Appendix K – Development of Alternatives

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Appendix K – Development of Alternatives

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

Appendix K – Development of Alternatives

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)

	Alternatives								
	NOAction	Alt1	Alt2	Alt3	Alt4	Alt5	Alt6	Alt7	
Glades				NO-Action					
Buford	NO-Action			Silver			Blue	Gold	
Morgan Falls				Flow-Thru					
Bear Creek				NO-Action					
West Point	NO-Action			Silver					
Bartletts Ferry				Flow-Thru					
Goat Rock				Flow-Thru					
Oliver				Flow-Thru					
North Highlands				Flow-Thru					
Walter F George	NO-Action			Silver					
George Andrews				Flow-Thru					
Jim Woodruff	NO-Action		Silver	Crimson	Orange	Peach	Blue	Gold	

Appendix K – Development of Alternatives

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

Measures		Alternatives							
		NOAction	Alt1	Alt2	Alt3	Alt4	Alt5	Alt6	
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.

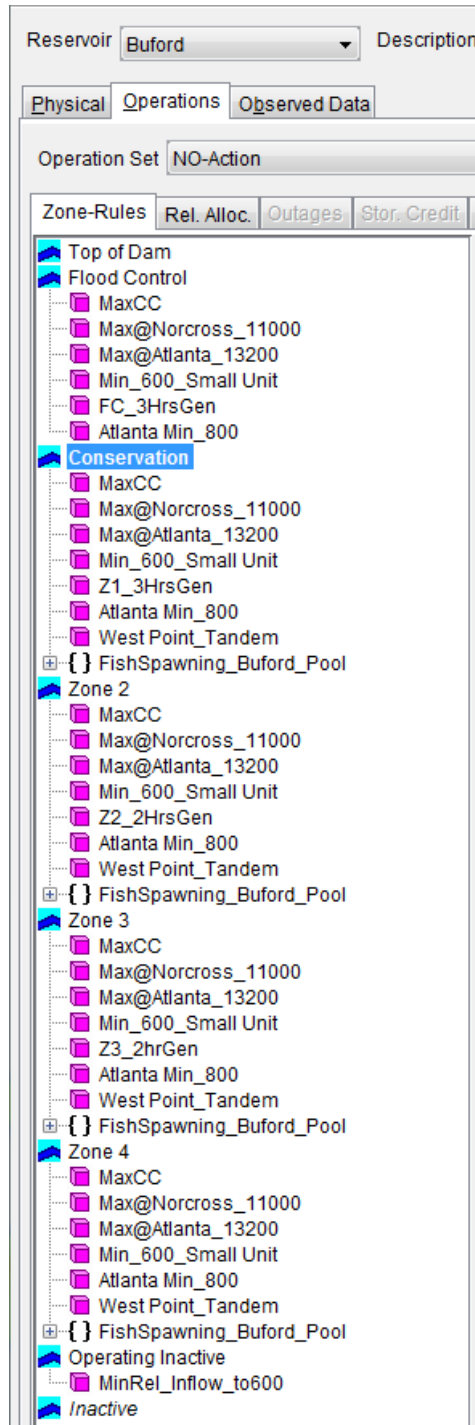


Figure K.01 Rule Set for Buford NO-Action Operation Set

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.

Appendix K – Development of Alternatives

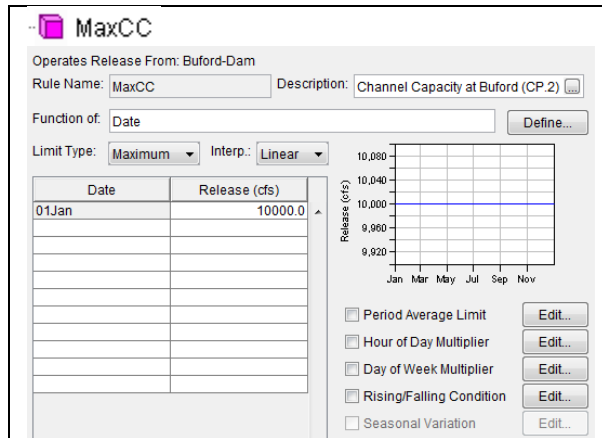


Figure K.02 MaxCC at Buford

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.

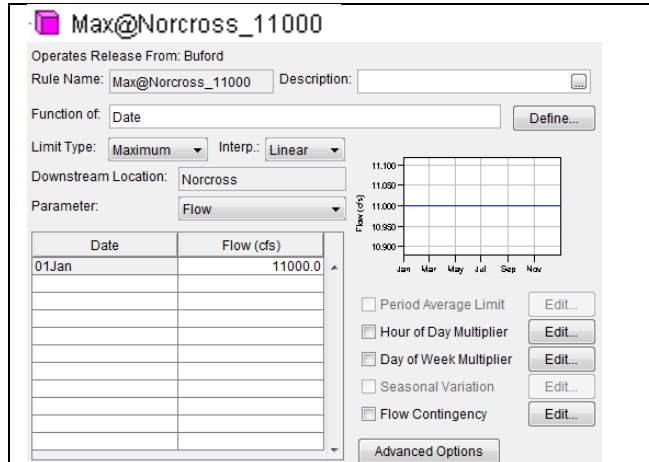


Figure K.03 Max@Norcross_11000 at Buford

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.

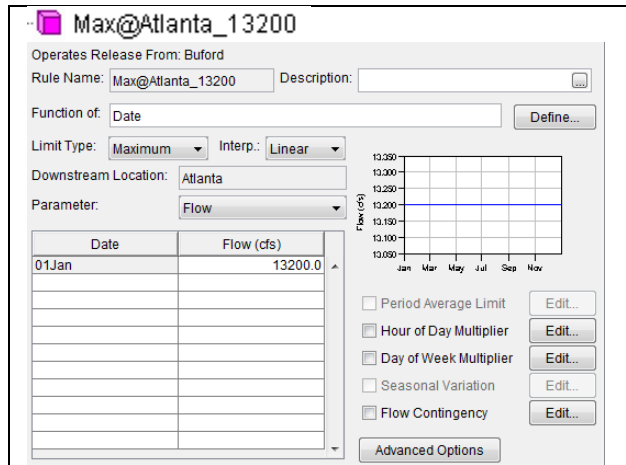


Figure K.04 Max@Atlanta_13200 at Buford

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.

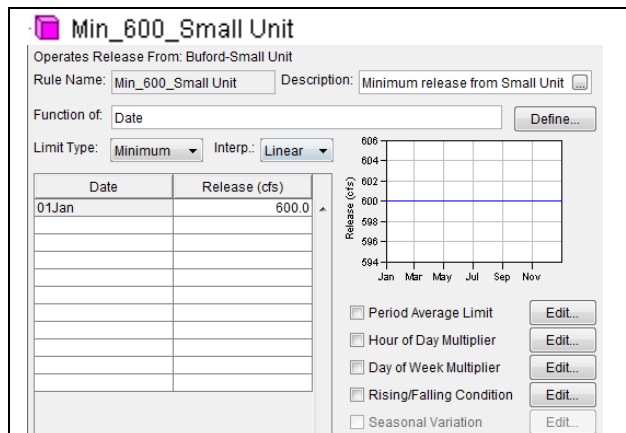


Figure K.05 Min_600_Small Unit at Buford

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.

Appendix K – Development of Alternatives

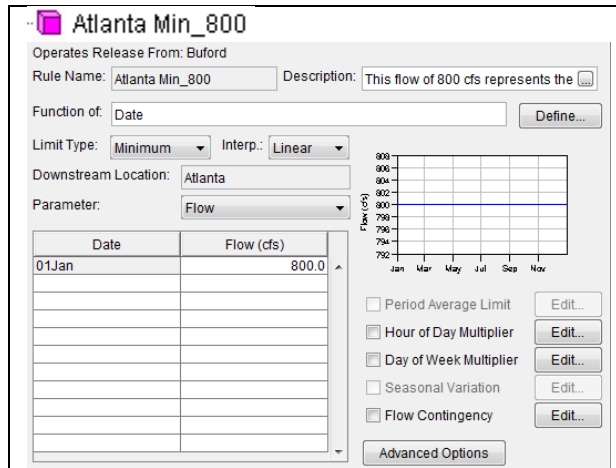


Figure K.06 Atlanta Min_800 at Buford

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.

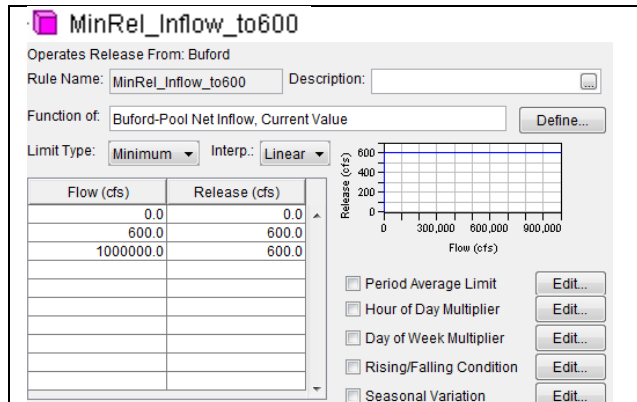


Figure K.07 MinRel_Inflow_to600 at Buford

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.

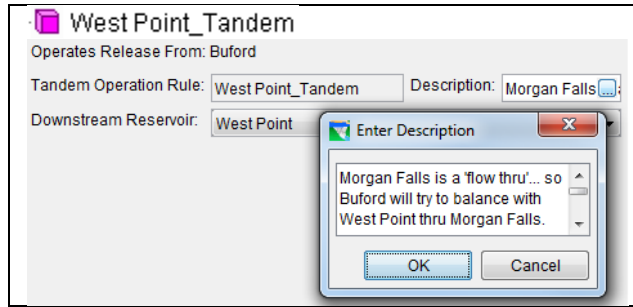


Figure K.08 West Point Tandem at Buford

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.

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 Generation Pattern...

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

Z1_3HrsGen (within *Conservation* zone)

Appendix K – Development of Alternatives

Z1_3HrsGen (within Zone 2)

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

Power Generation Pattern...

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

Power Generation Pattern...

Z3_2hrGen (within Zone 3)

Operates Release From: Buford-Power Plant
 Hydropower - Power Guide Curve Rule: Z3_2hrGen
 Description: 2 hours of generation at full capacity

Zone at Top of Power Pool: Zone 3
 Zone at Bottom of Power Pool: Zone 4

% Power Storage	Plant Factor (%)
0.0	8.3
100.0	8.3

Power Generation Pattern...

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

Power Generation Pattern

Seasonal Variation: [] Edit...

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

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

OK Cancel

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:

```

5 # State variable: Buford_Elev_State
6 # Code =0: Pool is rising
7 #     =1: The first day of the fish spawning
8 #     =2: The pool has dropped within 0.3 ft from the base elevation
9 #     =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #    =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #    =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #    =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #    =7: The pool has dropped more than 0.50 ft from the base elevation
14

```

Appendix K – Development of Alternatives

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

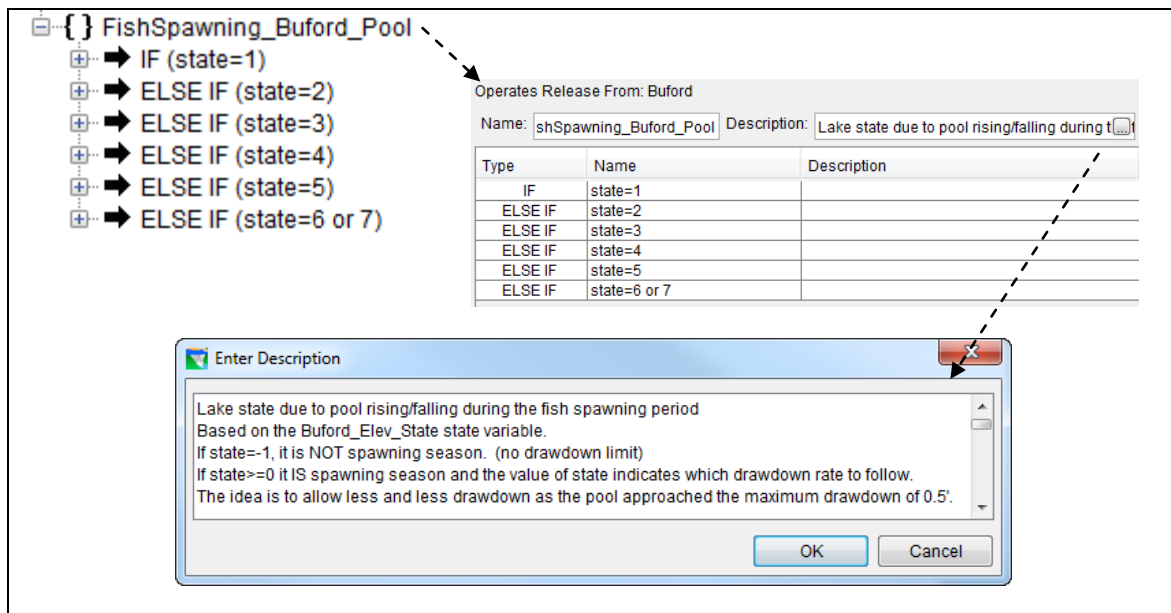


Figure K.10 Fish Spawning -- “Conditional Blocks” at Buford

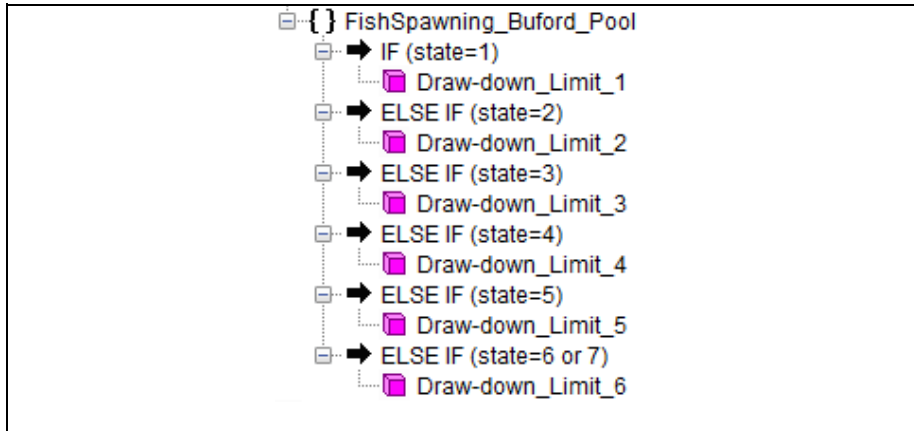


Figure K.11 Fish Spawning -- “IF-Blocks” and “Rules” at Buford

Appendix K – Development of Alternatives

The image displays a software interface for defining rules and limits. It is organized into two columns. The left column contains three conditional rules, and the right column contains three corresponding draw-down limit rules.

IF (state=1)
 Operates Release From: Buford-Dam
 IF Conditional: state=1
 Description: []

Value1	Value2
Buford_Elev_State	= 1

 Logical Operator: []
 Value 1: Time Series (Buford_Elev_State, Current Value)
 Operator: =
 Value 2: Constant (1)

ELSE IF (state=2)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=2
 Description: []

Value1	Value2
Buford_Elev_State	= 2

 Logical Operator: []
 Value 1: Time Series (Buford_Elev_State, Current Value)
 Operator: =
 Value 2: Constant (2)

ELSE IF (state=3)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=3
 Description: []

Value1	Value2
Buford_Elev_State	= 3

 Logical Operator: []
 Value 1: Time Series (Buford_Elev_State, Current Value)
 Operator: =
 Value 2: Constant (3)

Draw-down_Limit_1
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_1
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.1 over 24 hours

Draw-down_Limit_2
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_2
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.2 over 24 hours

Draw-down_Limit_3
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_3
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.1 over 24 hours

Figure K.12 Fish Spawning – Rules for “Buford_Elev_State” Values (Part 1 of 2) at Buford

The image displays three 'ELSE IF' rule configurations and three 'Draw-down_Limit' configurations for 'Buford_Elev_State' values.

ELSE IF (state=4)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=4
 Description: []

Value1	Value2
Buford_Elev_State	= 4

 Logical Operator: []
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: =
 Value 2: Constant, 4

Draw-down_Limit_4
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_4
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.05 over 24 hours

ELSE IF (state=5)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=5
 Description: []

Value1	Value2
Buford_Elev_State	= 5

 Logical Operator: []
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: =
 Value 2: Constant, 5

Draw-down_Limit_5
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_5
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.01 over 24 hours

ELSE IF (state=6 or 7)
 Operates Release From: Buford-Dam
 ELSE IF Conditional: state=6 or 7
 Description: []

Value1	Value2
Buford_Elev_State	>= 6

 Logical Operator: []
 Value 1: Time Series, Buford_Elev_State, Current Value
 Operator: >=
 Value 2: Constant, 6

Draw-down_Limit_6
 Operates Release From: Buford
 Elevation Rate of Change Limit: Draw-down_Limit_6
 Description: []
 Function Of: Constant
 Type: Decreasing
 Instantaneous
 Period Average
 Max Change of (ft) 0.0 over 24 hours

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.

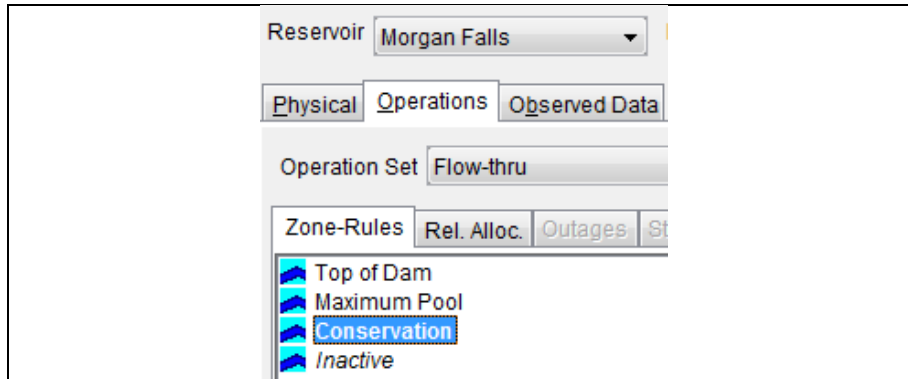


Figure K.14 Rule Set for Morgan Falls Flow-thru Operation Set

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.

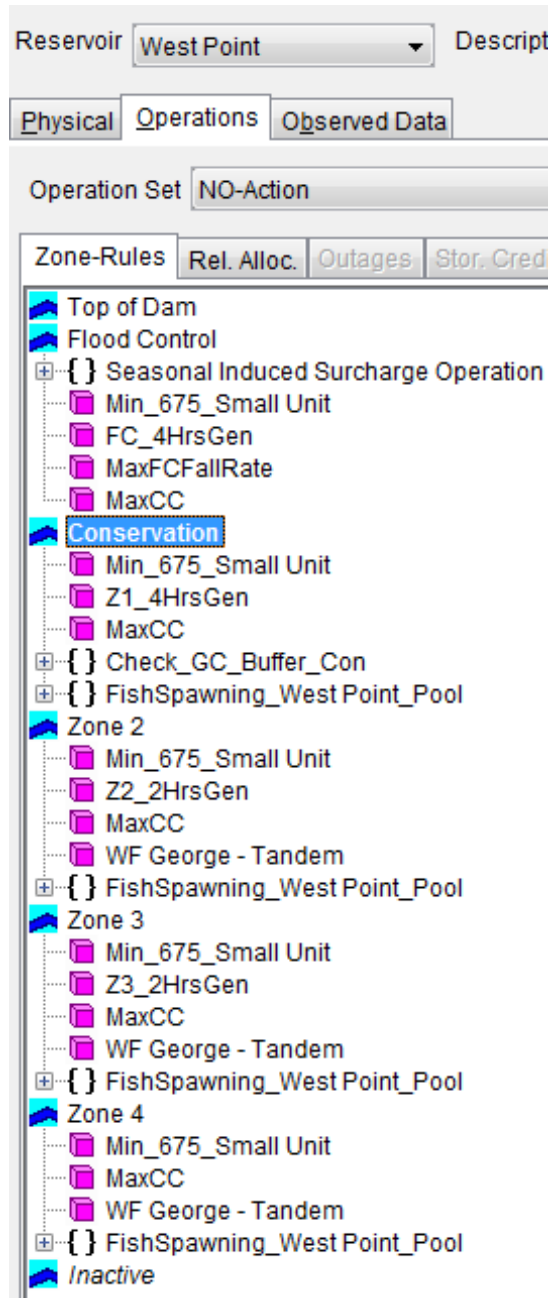


Figure K.15 Rule Set for West Point NO-Action Operation Set

Appendix K – Development of Alternatives

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.

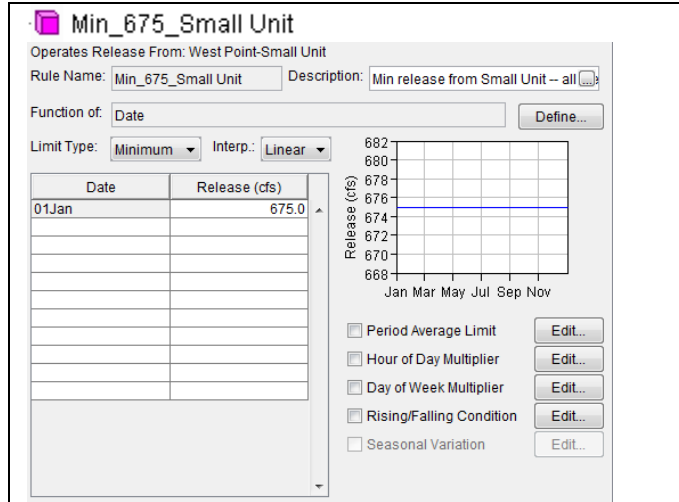


Figure K.16 *Min_675_Small Unit* at West Point

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.

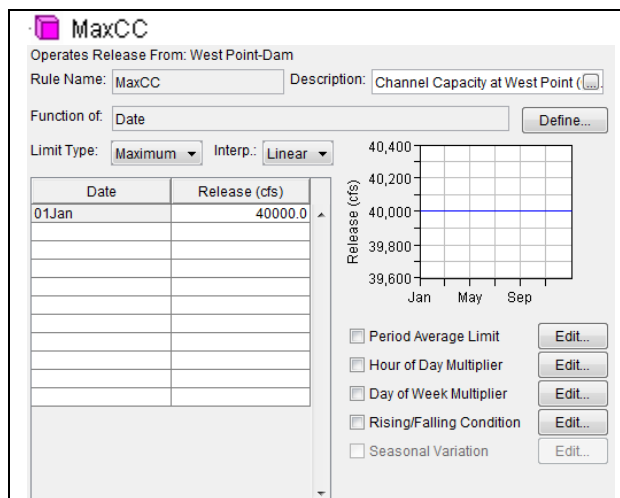


Figure K.17 *MaxCC* at West Point

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.

The screenshot shows a configuration window for the 'MaxFCFallRate' rule. The window has a title bar with a pink icon and the text 'MaxFCFallRate'. Below the title bar, there are several fields and dropdown menus:

- 'Operates Release From: West Point' (text field)
- 'Release Rate of Change Limit: MaxFCFallRate' (text field)
- 'Description: Max drawdown rate of flood pool' (text field)
- 'Function Of: Constant' (dropdown menu)
- 'Type: Decreasing' (dropdown menu)
- 'Max Rate of Change (cfs/hr): 3000.0' (text field)

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.

The screenshot shows a configuration window for the 'WF George - Tandem' rule. The window has a title bar with a pink icon and the text 'WF George - Tandem'. Below the title bar, there are several fields and a dropdown menu:

- 'Operates Release From: West Point' (text field)
- 'Tandem Operation Rule: WF George - Tandem' (text field)
- 'Description: [empty]' (text field with a small icon to its right)
- 'Downstream Reservoir: Walter F George' (dropdown menu)

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).

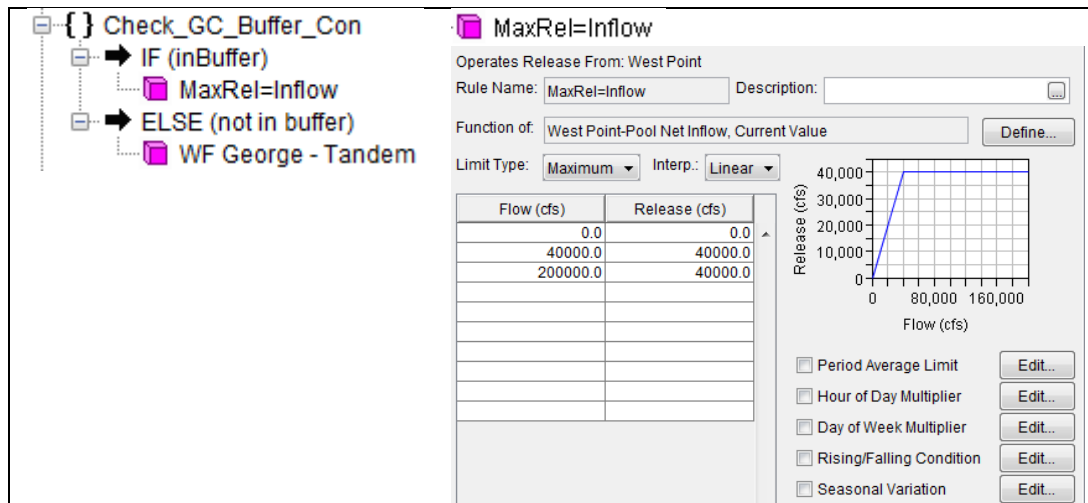


Figure K.20 {} Check_GC_Buffer_Con at West Point

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.

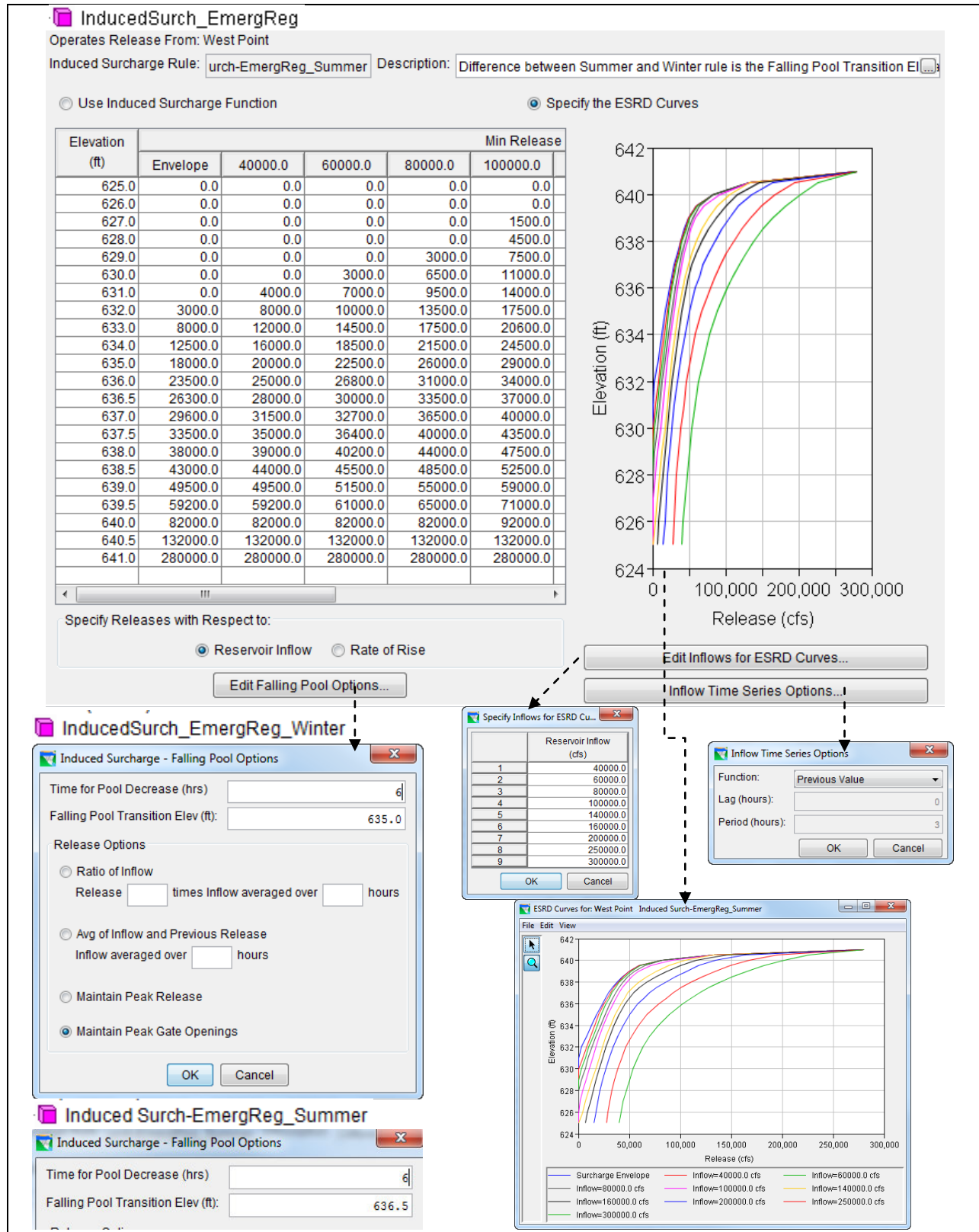


Figure K.21 *InducedSurch_EmergReg* at West Point

Appendix K – Development of Alternatives

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.

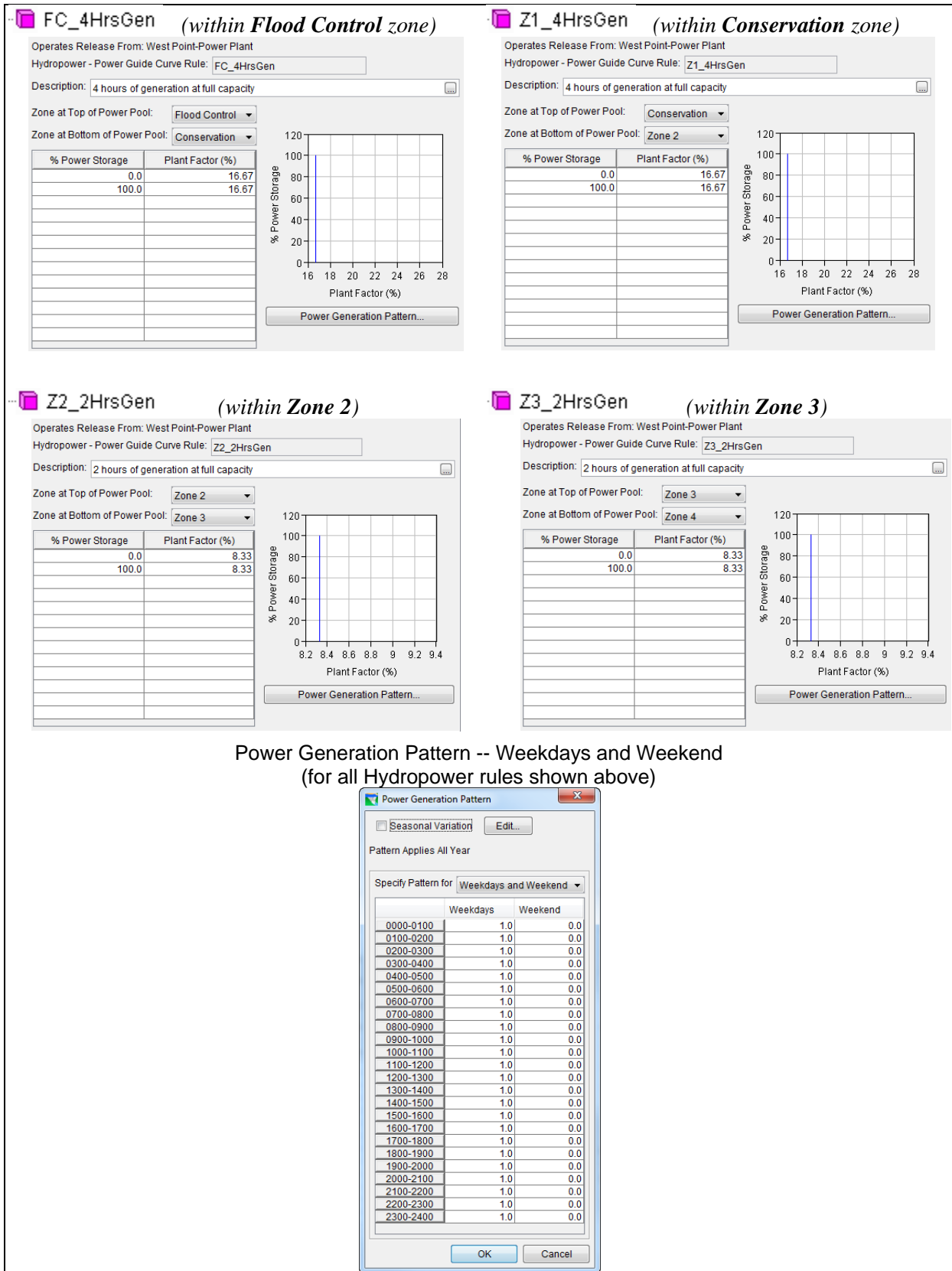


Figure K.22 Hydropower Rules at West Point

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:

```
5 # State variable: WestPoint_Elev_State
6 # Code=0: Pool is rising
7 #     =1: The first day of the fish spawning
8 #     =2: The pool has dropped within 0.3 ft from the base elevation
9 #     =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #    =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #    =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #    =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #    =7: The pool has dropped more than 0.50 ft from the base elevation
```

Appendix K – Development of Alternatives

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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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

Appendix K – Development of Alternatives

The screenshot displays a software interface for configuring a conditional block. On the left, a tree view shows a folder named 'FishSpawning_WestPoint_Pool' containing six conditional blocks: 'IF (state=1)', 'ELSE IF (state=2)', 'ELSE IF (state=3)', 'ELSE IF (state=4)', 'ELSE IF (state=5)', and 'ELSE IF (state=6 or 7)'. A dashed arrow points from the 'IF (state=1)' block to a configuration window on the right. This window, titled 'Operates Release From: West Point', has a 'Name' field containing 'pawning_WestPoint_Pool' and a 'Description' field containing 'Lake state during the fish spawning period'. Below these fields is a table with three columns: 'Type', 'Name', and 'Description'. The table lists the conditional blocks and their corresponding state values.

Type	Name	Description
IF	state=1	
ELSE IF	state=2	
ELSE IF	state=3	
ELSE IF	state=4	
ELSE IF	state=5	
ELSE IF	state=6 or 7	

Below the configuration window is a dialog box titled 'Enter Description'. It contains the following text:

Lake state during the fish spawning period
 Based on the WestPoint_Elev_State state variable.
 If state=-1, it is NOT spawning season. (no drawdown limit)
 If state>=0 it IS spawning season and the value of state indicates which drawdown rate to follow.
 The idea is to allow less and less drawdown as the pool approached the maximum drawdown of 0.5'.

The dialog box has 'OK' and 'Cancel' buttons at the bottom right. A dashed arrow points from the 'Description' field in the configuration window to the dialog box.

Figure K.23 Fish Spawning -- “Conditional Blocks” at West Point

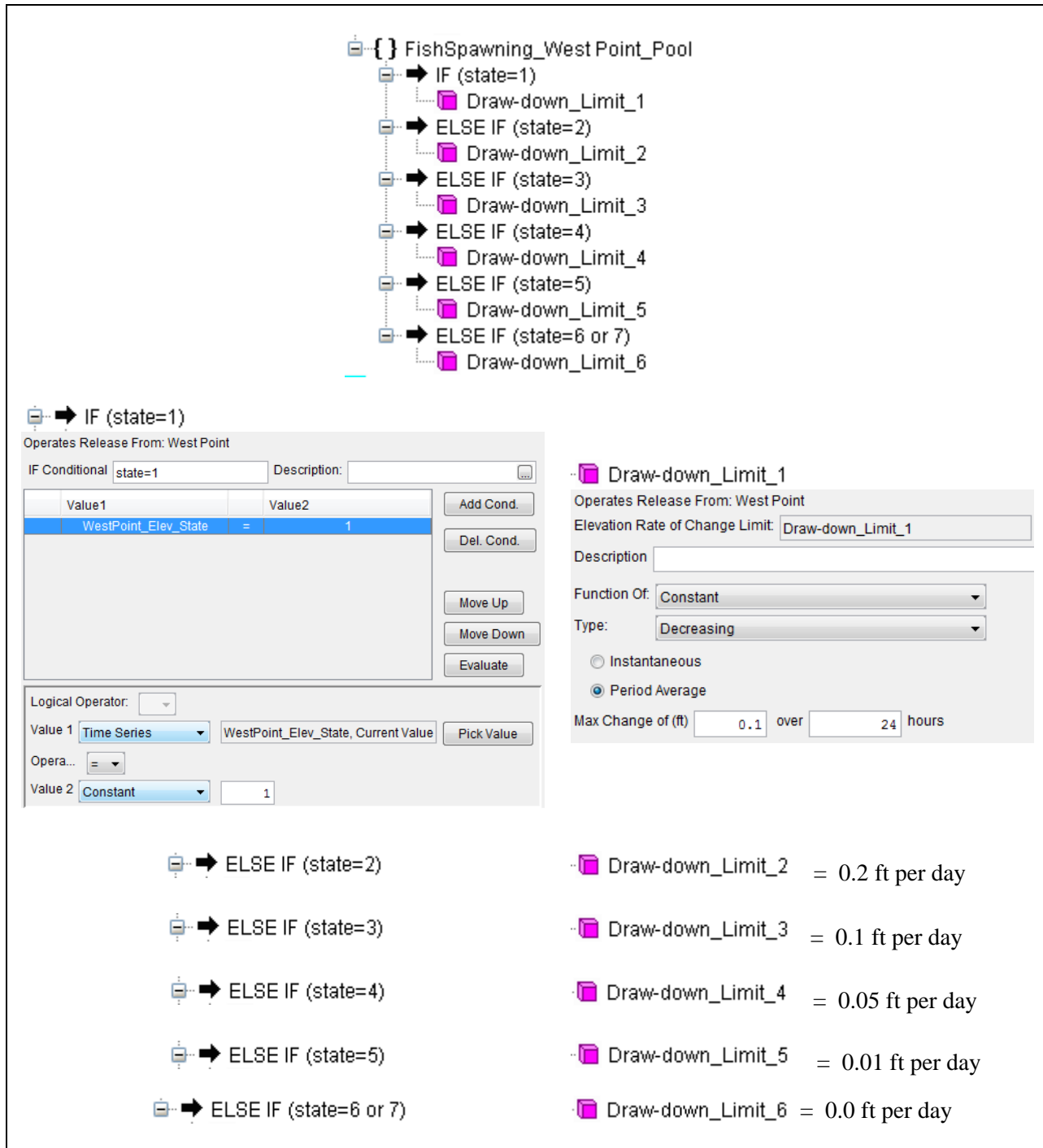


Figure K.24 Fish Spawning -- “IF-Blocks” and “Rules” and “WestPoint_Elev_State” Values at West Point

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.

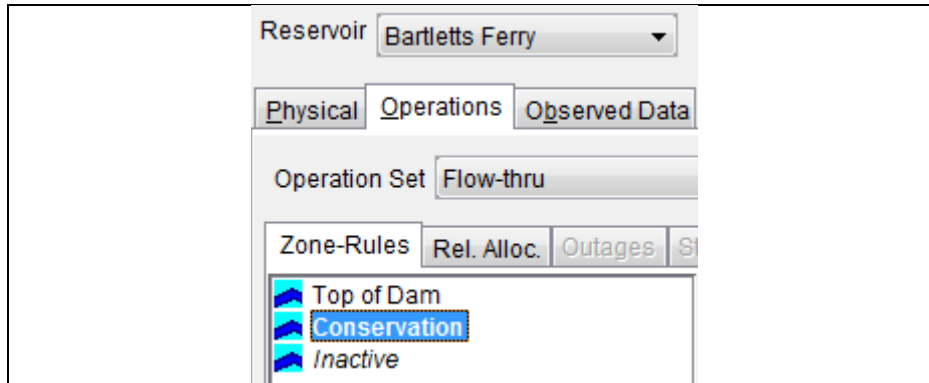


Figure K.25 Rule Set for Bartletts Ferry Flow-thru Operation Set

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.

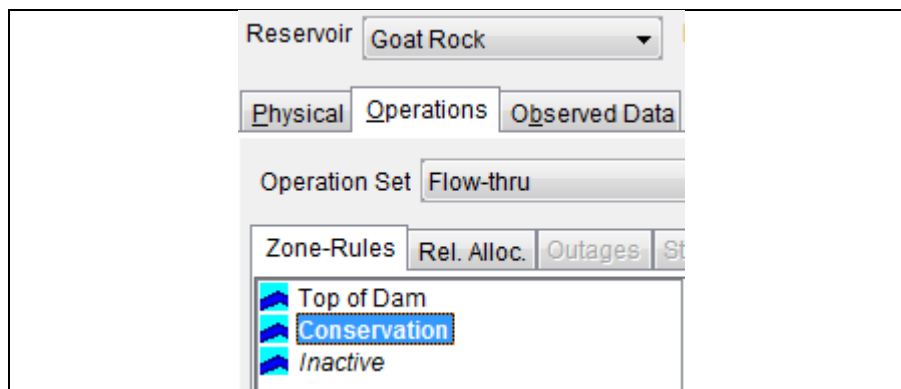


Figure K.26 Rule Set for Goat Rock Flow-thru Operation Set

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.

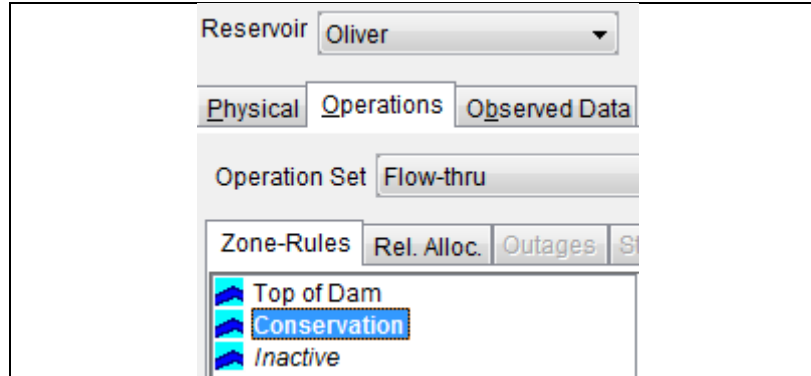


Figure K.27 Rule Set for Oliver Flow-thru Operation Set

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.

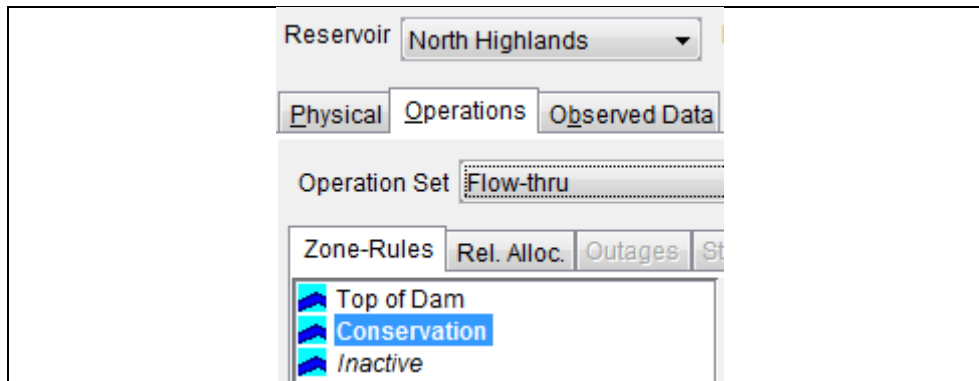


Figure K.28 Rule Set for North Highlands Flow-thru Operation Set

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.

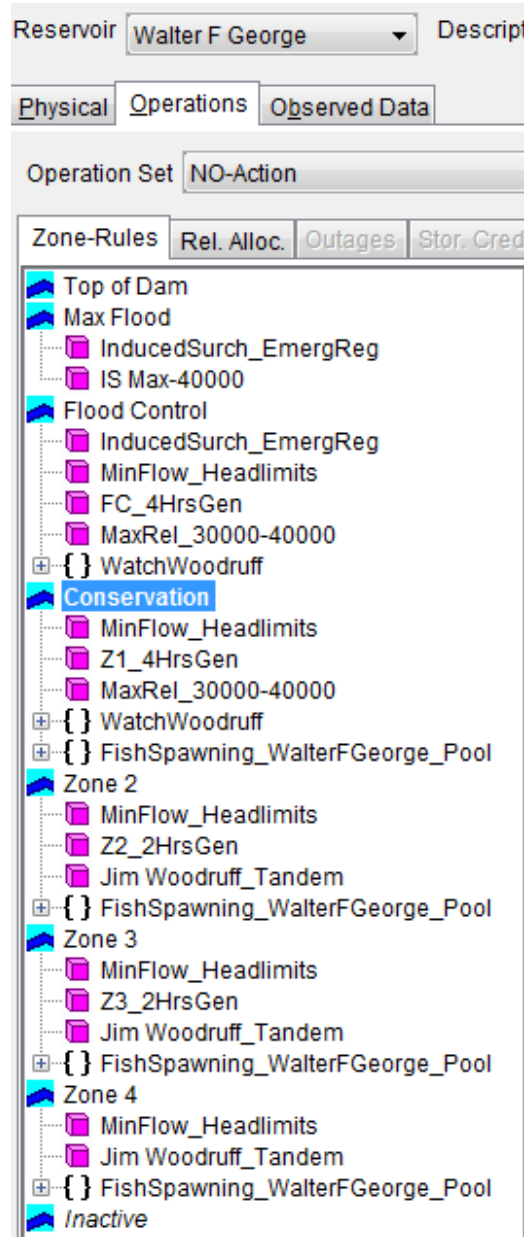


Figure K.29 Rule Set for Walter F George NO-Action Operation Set

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.

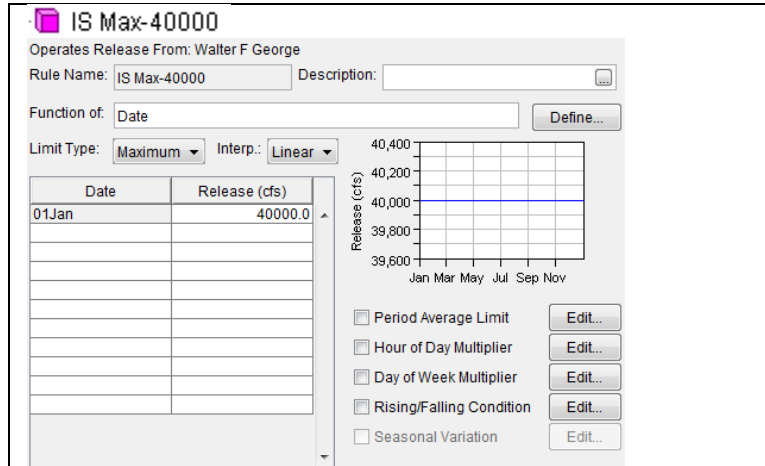


Figure K.30 ISMax-40000 at Walter F George

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, “WFGGeorge_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.

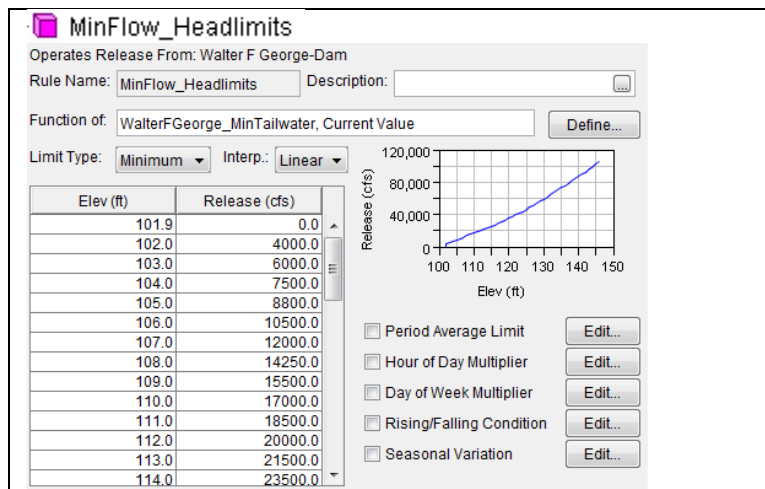


Figure K.31 MinFlow-Headlimits at Walter F George

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.

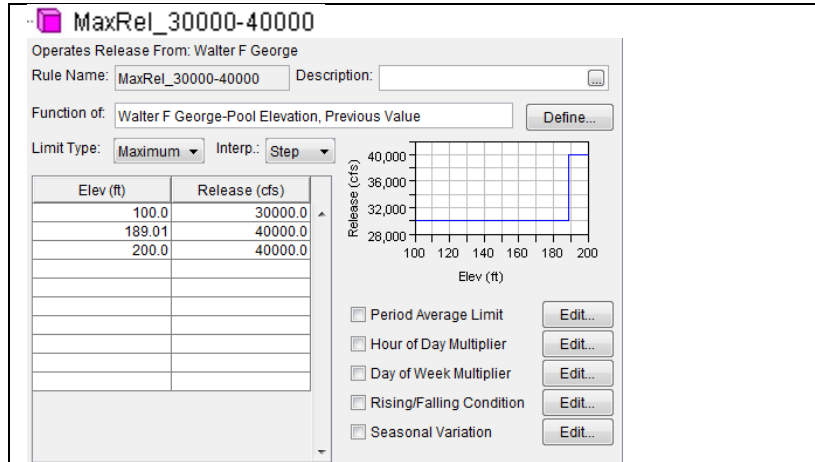


Figure K.32 MaxRel_30000-40000 at Walter F George

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.

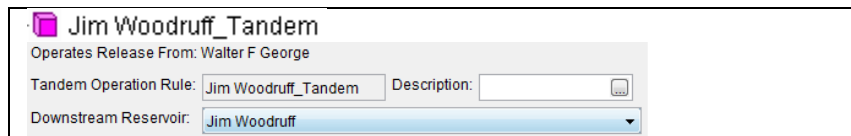


Figure K.33 JimWoodruff_Tandem at Walter F George

5. {} WatchWoodruff

This conditional logic (see Figure K.34) activates the tandem operation when the pool elevation at Lake Seminole is in Zone 1.

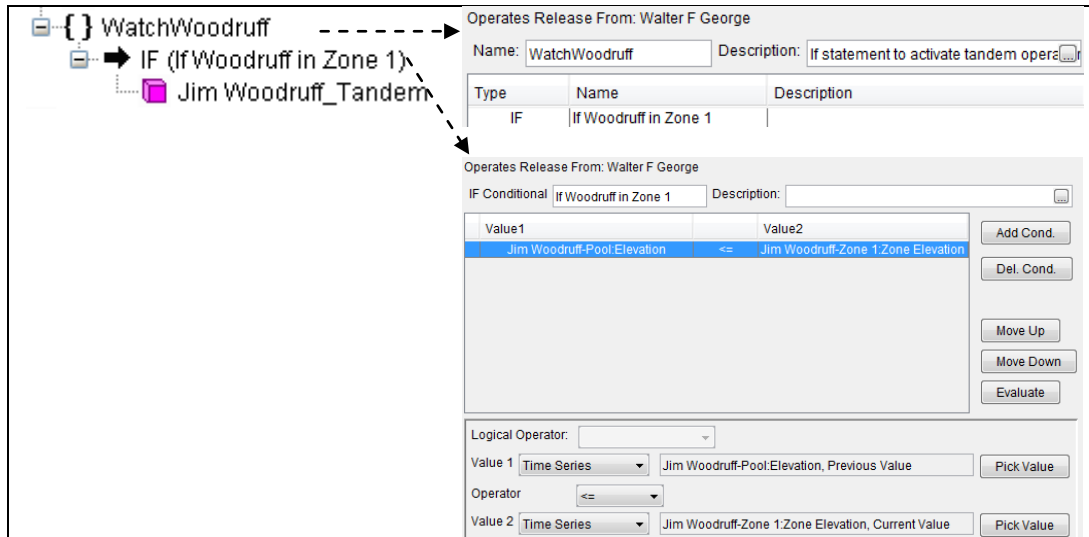


Figure K.34 {} WatchWoodruff at Walter F George

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.

Appendix K – Development of Alternatives

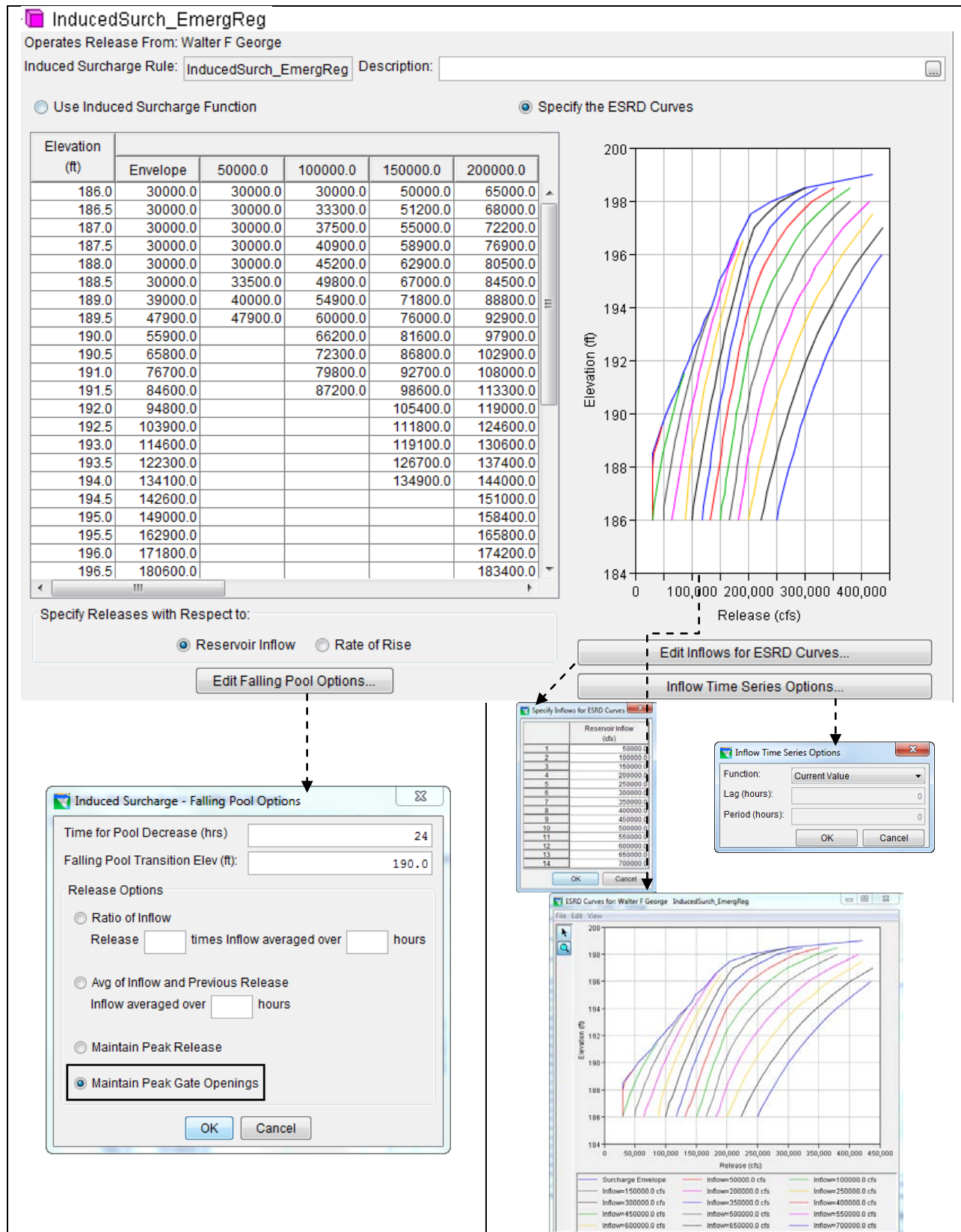


Figure K.35 InducedSurch_EmergReg at Walter F George

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.

Appendix K – Development of Alternatives

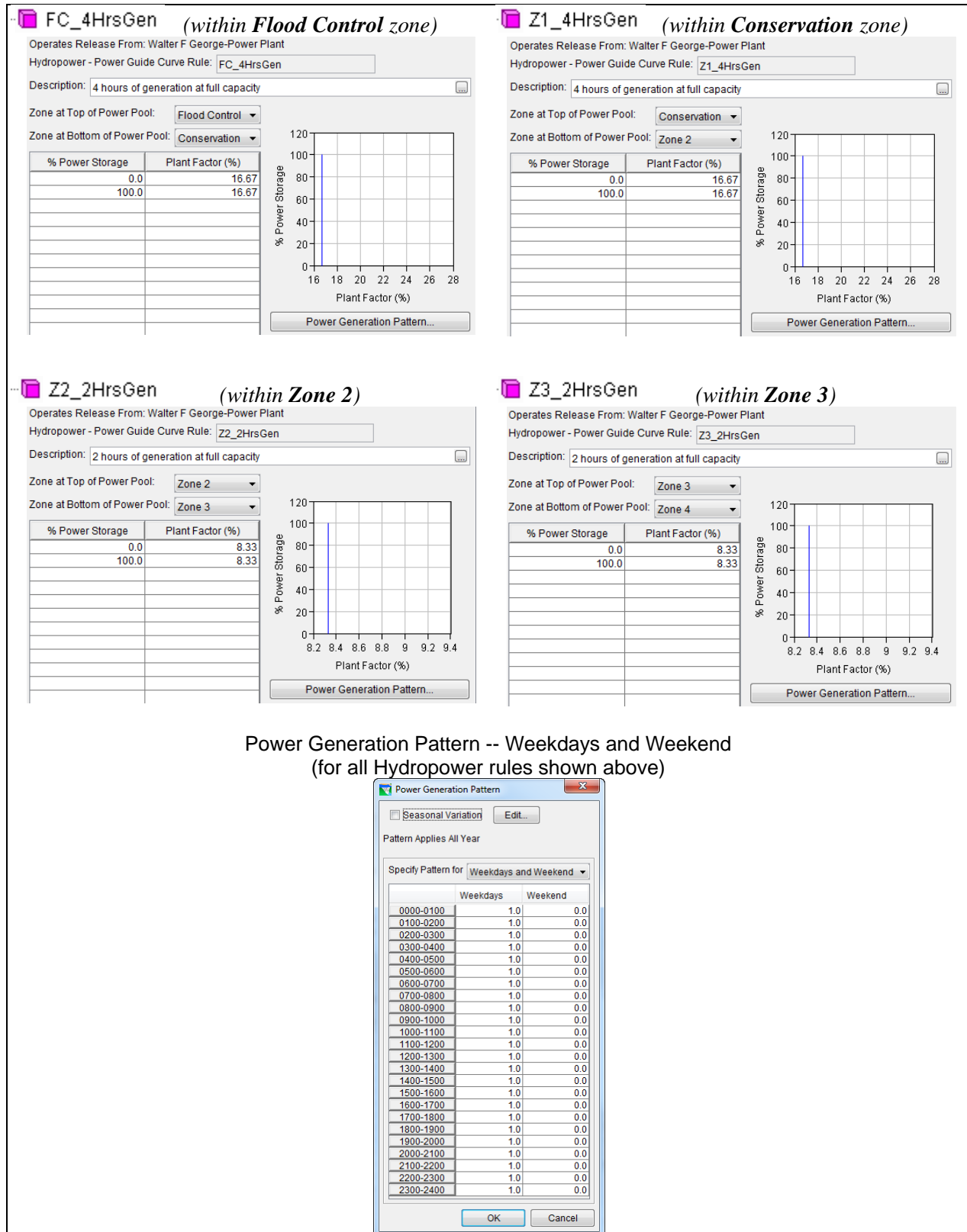


Figure K.36 Hydropower Rules at Walter F George

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:

```
5 # State variable: WalterFGeorge_Elev_State
6 # Code=0: Pool is rising
7 #   =1: The first day of the fish spawning
8 #   =2: The pool has dropped within 0.3 ft from the base elevation
9 #   =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #  =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #  =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #  =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #  =7: The pool has dropped more than 0.50 ft from the base elevation
```

Appendix K – Development of Alternatives

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):

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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

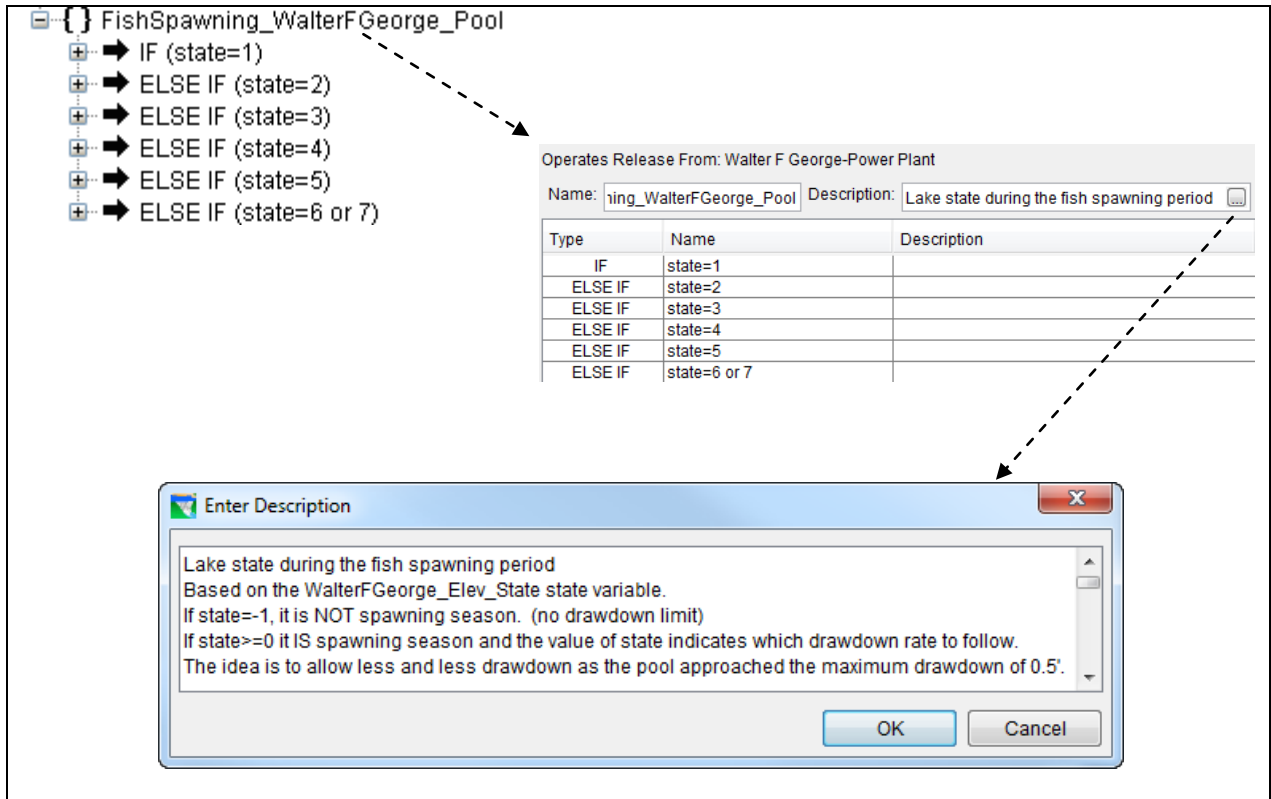


Figure K.37 Fish Spawning -- “Conditional Blocks” at Walter F George

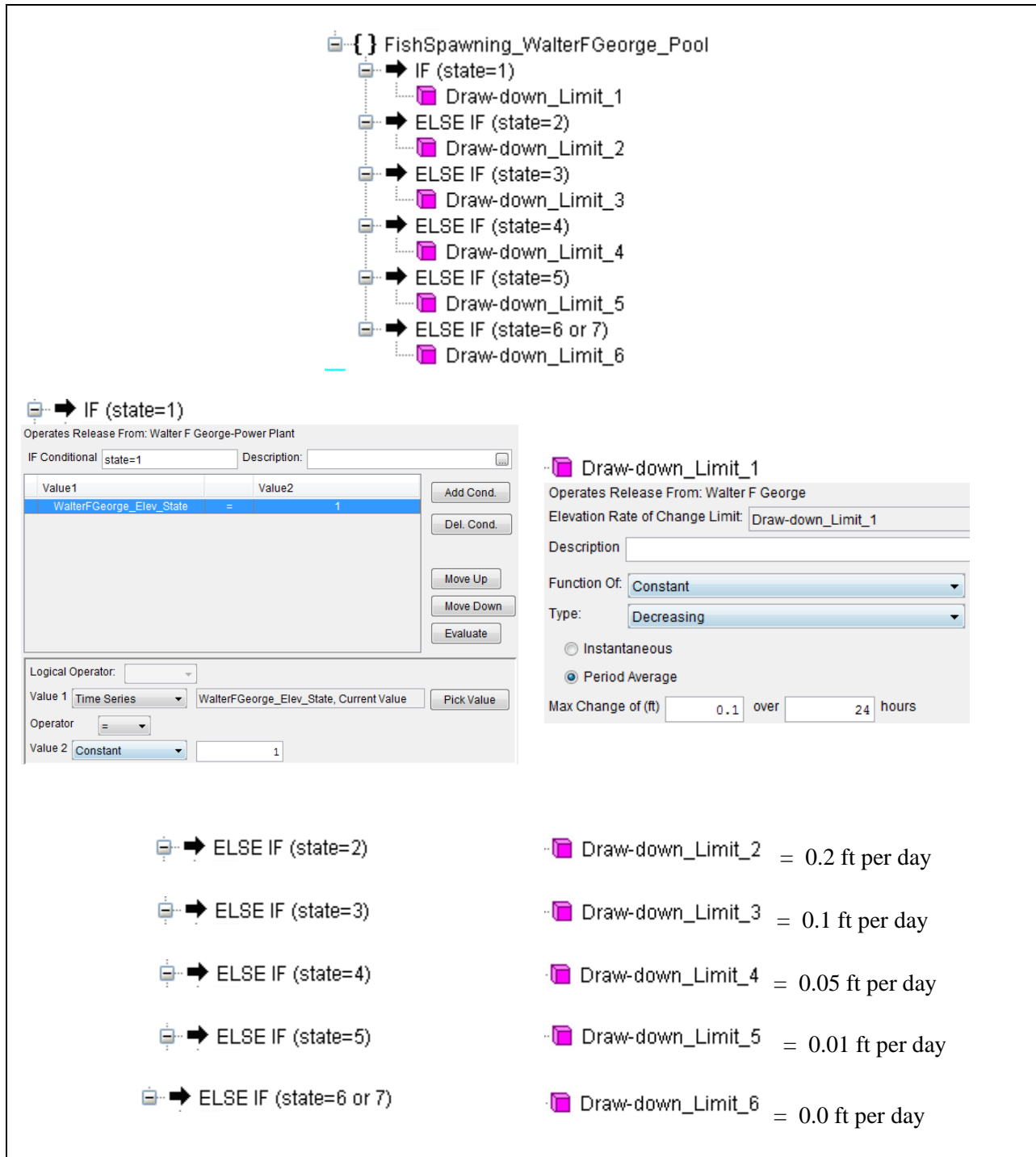


Figure K.38 Fish Spawning -- “IF-Blocks” and “Rules” and “WalterFGeorge_Elev_State” Values at Walter F George

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.

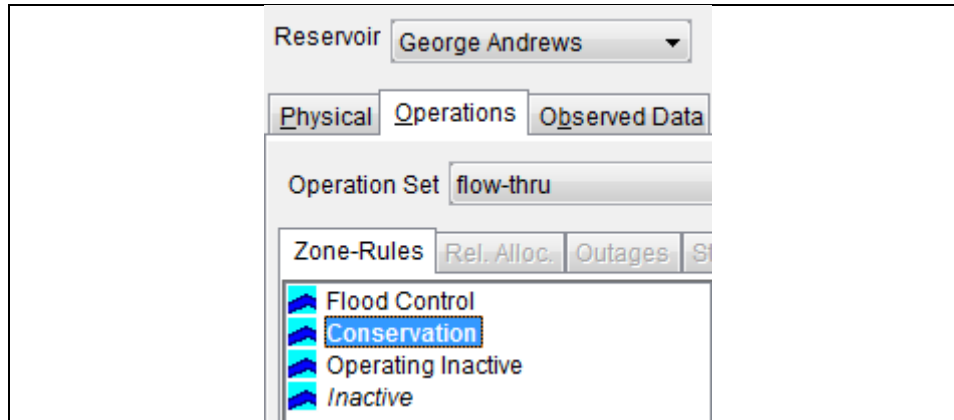


Figure K.39 Rule Set for George Andrews Flow-thru Operation Set

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.

Appendix K – Development of Alternatives

Reservoir **Jim Woodruff** Descrip

Physical **Operations** Observed Data

Operation Set **No-action**

Zone-Rules Rel. Alloc. Outages Stor. Cre

- Top of Dam
- Flood Control
 - MinRel_HeadLimit
- Conservation
 - MinRel_HeadLimit
 - { } Flow Target
 - { } Ramp_Rate_DO4-1
 - { } Sturgeon Spawning
 - { } Fish Spawning_Apalachicola River
 - { } Fish Spawning_JimWoodruff_Pool
- Zone 1
 - MinRel_HeadLimit
 - { } Flow Target
 - { } Ramp_Rate_DO4-1
 - { } Sturgeon Spawning
 - { } Fish Spawning_Apalachicola River
 - { } Fish Spawning_JimWoodruff_Pool
- Zone 2
 - MinRel_HeadLimit
 - { } Flow Target
 - { } Ramp_Rate_DO4-1
 - { } Sturgeon Spawning
 - { } Fish Spawning_Apalachicola River
 - { } Fish Spawning_JimWoodruff_Pool
- Zone 3
 - MinRel_HeadLimit
 - { } Flow Target
 - { } Ramp_Rate_DO4-1
 - { } Sturgeon Spawning
 - { } Fish Spawning_Apalachicola River
 - { } Fish Spawning_JimWoodruff_Pool
- Zone 4
 - MinRel_HeadLimit
 - { } Flow Target
 - { } Ramp_Rate_DO4-1
 - { } Sturgeon Spawning
 - { } Fish Spawning_Apalachicola River
 - { } Fish Spawning_JimWoodruff_Pool
- Operating Inactive
 - { } Release Inflow up to Minimum Reqmt
- Inactive

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.

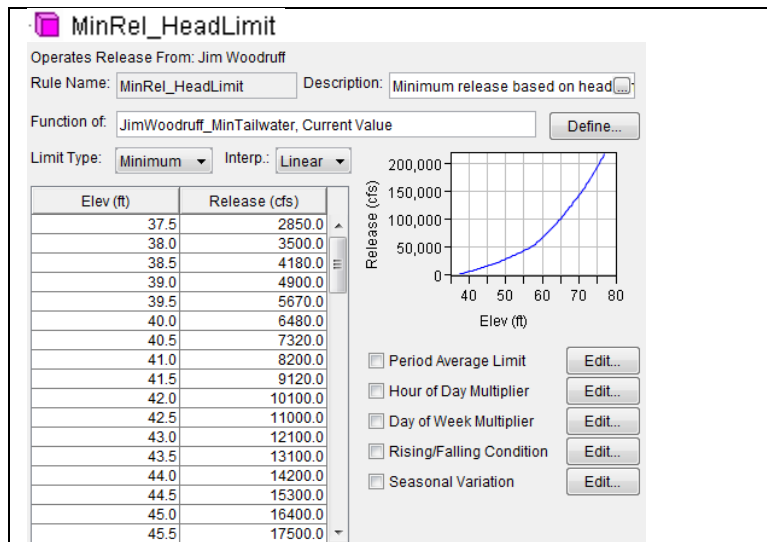


Figure K.41 MinRel_Headlimit at Jim Woodruff

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.

Appendix K – Development of Alternatives

**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:

Appendix K – Development of Alternatives

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_D04-1

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).

Appendix K – Development of Alternatives

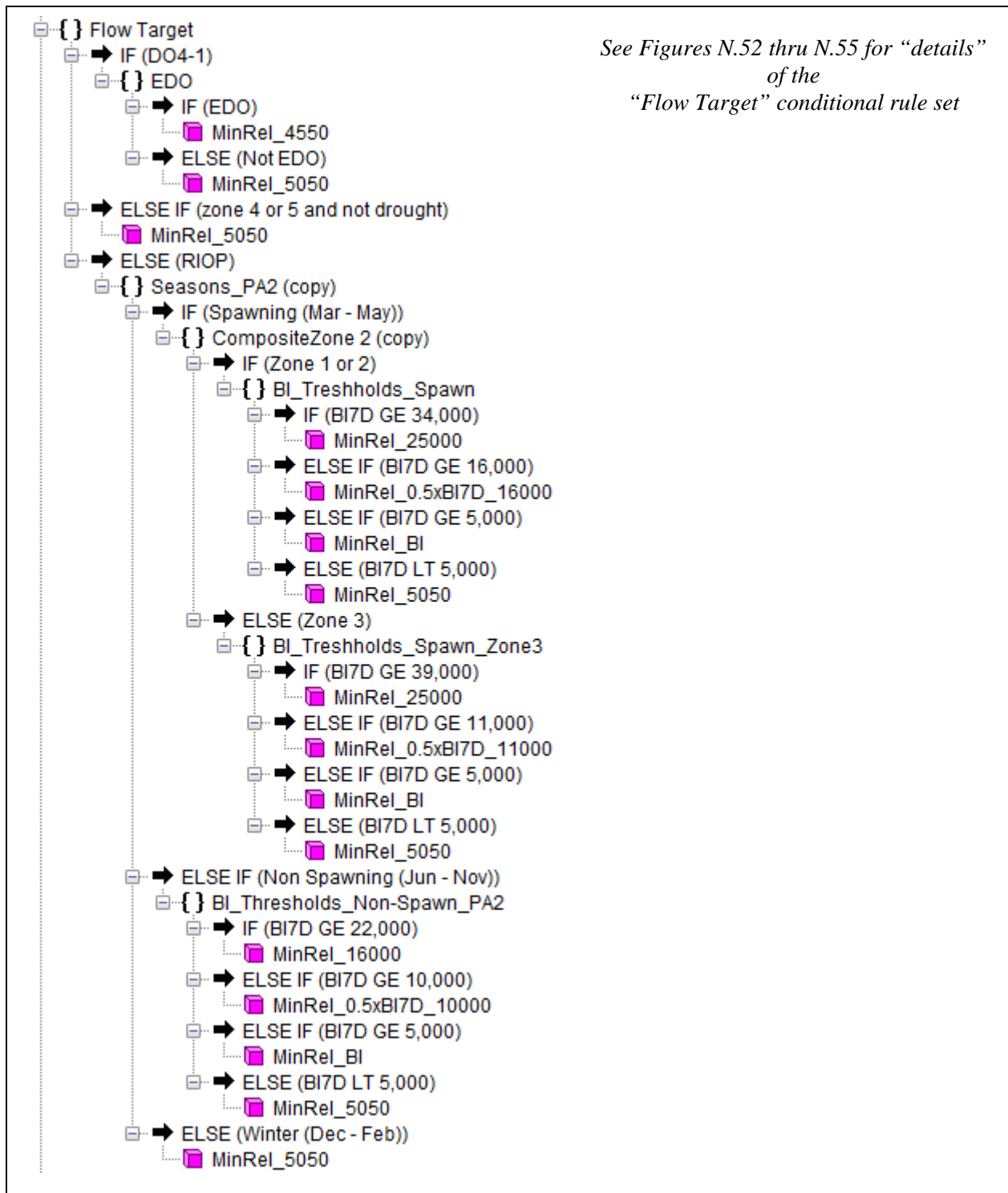


Figure K.42 NO-Action OpSet -- ESA Conditional Rule Set at Jim Woodruff

Flow Target Configuration Overview

IF Conditional: DO4-1

Value1	Value2
Drought_Ops_4_1	= 1

Logical Operator: []
 Value 1: Time Series | Drought_Ops_4_1, Current Value | Pick Value
 Operator: =
 Value 2: Constant | 1

ELSE IF Conditional: zone 4 or 5 and not drought

Value1	Value2
CompositeStorage	>= 4

Logical Operator: []
 Value 1: Time Series | CompositeStorage, Current Value | Pick Value
 Operator: >=
 Value 2: Constant | 4

ELSE Conditional: RIOP

Figure K.43 ESA (Part 1 of 4): Overview of “IF (DO4-1) - Else IF (Zone 4 or 5 and not drought) -Else (RIOP)”

Appendix K – Development of Alternatives

The screenshot displays a software interface for configuring drought operations. On the left, a flowchart shows a hierarchy starting with 'Flow Target', leading to 'IF (DO4-1)', then 'EDO', and further branching into 'IF (EDO)' (with 'MinRel_4550') and 'ELSE (Not EDO)' (with 'MinRel_5050'). Below this is another 'EDO' block with similar logic. A third 'IF Conditional EDO' window shows a table with 'EDO_Flow' and '1' connected by an equals sign. On the right, three detailed rule configuration windows are shown:

- EDO Rule:** Name: EDO, Description: (empty). A table lists 'IF EDO' and 'ELSE Not EDO'. The 'ELSE Conditional' is set to 'Not EDO'.
- EDO_4550 Rule:** Operates Release From: Jim Woodruff, Rule Name: MinRel_4550. Function of: Date. Limit Type: Minimum, Interp.: Linear. A table shows '01Jan' with a release of 4550.0 cfs. A graph shows a constant release of 4550 cfs from Jan to Nov. Options for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation are all unchecked.
- MinRel_5050 Rule:** Operates Release From: Jim Woodruff, Rule Name: MinRel_5050, Description: This flow of 5050 cfs represents the r... Function of: Date. Limit Type: Minimum, Interp.: Linear. A table shows '01Jan' with a release of 5050.0 cfs. A graph shows a constant release of 5050 cfs from Jan to Nov. Options for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation are all unchecked.

Figure K.44 ESA (Part 2 of 4): Drought Operations ,Checking for “EDO” , “MinRel_4550”and Not EDO, “MinRel_5050”

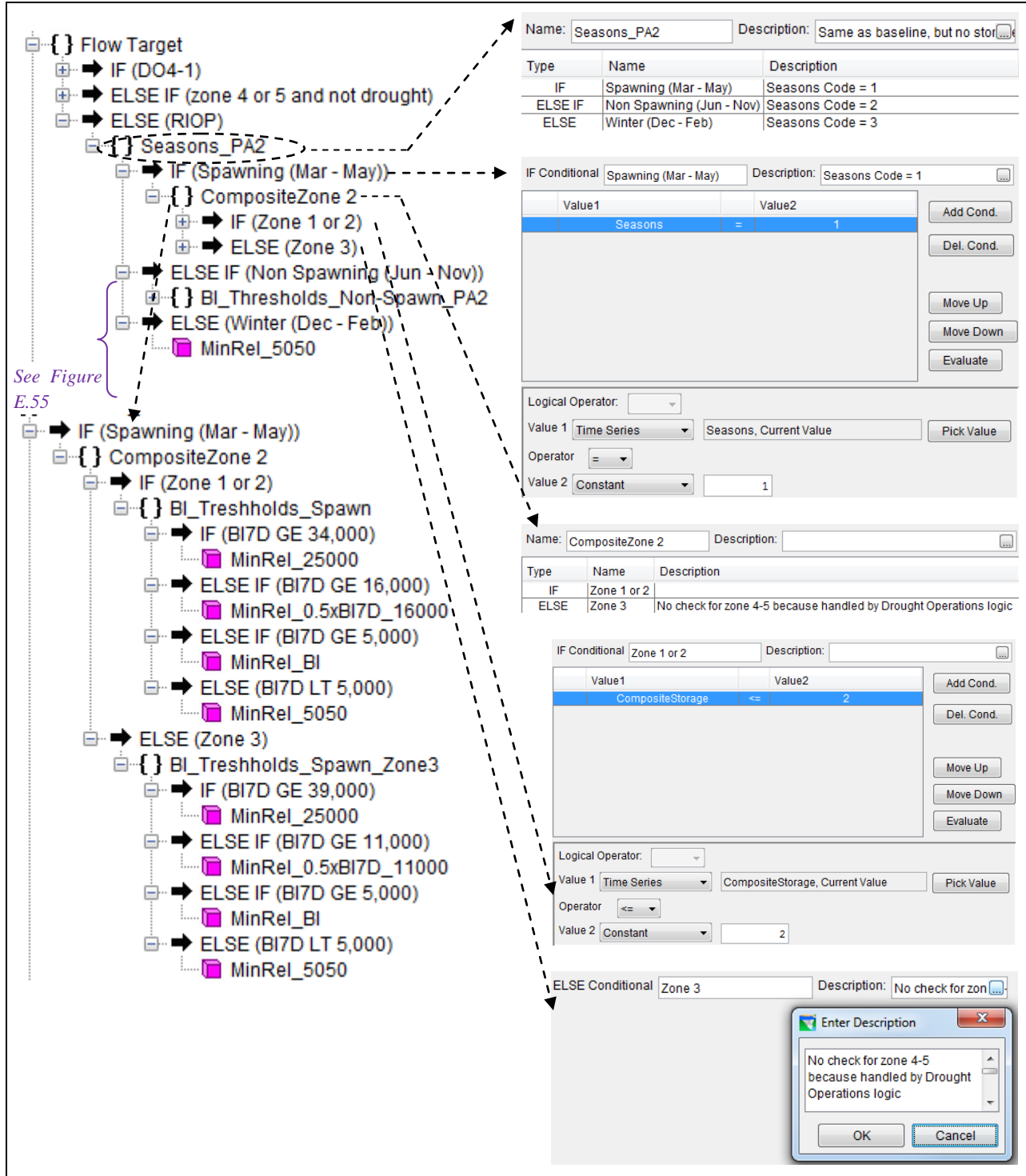


Figure K.45 ESA (Part 3 of 4): Seasons – Part 1 of 2 – “Overview” and check for “Spawning (Mar-May)”

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Seasons_PA2

- IF (Spawning (Mar - May))
- ELSE IF (Non Spawning (Jun - Nov))
 - BI_Thresholds_Non-Spaw_PA2**
 - IF (BI7D GE 22,000)
 - MinRel_16000
 - ELSE IF (BI7D GE 10,000)
 - MinRel_0.5xBI7D_10000
 - ELSE IF (BI7D GE 5,000)
 - MinRel_BI
 - ELSE (BI7D LT 5,000)
 - MinRel_5050
- ELSE (Winter (Dec - Feb))
 - MinRel_5050

BI_Thresholds_Non-Spaw

Type	Name	Description
IF	BI7D GE 22,000	
ELSE IF	BI7D GE 10,000	
ELSE IF	BI7D GE 5,000	
ELSE	BI7D LT 5,000	

BI_Thresholds_Non-Spaw_PA2

- IF (BI7D GE 22,000)
 - MinRel_16000
- ELSE IF (BI7D GE 10,000)
 - MinRel_0.5xBI7D_10000
- ELSE IF (BI7D GE 5,000)
 - MinRel_BI
- ELSE (BI7D LT 5,000)
 - MinRel_5050

MinRel_16000

Operates Release From: Jim Woodruff
 Rule Name: MinRel_16000
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	16000.0

MinRel_0.5xBI7D_10000

Operates Release From: Jim Woodruff
 Rule Name: MinRel_0.5xBI7D_10000 Description: min=10,000 cfs plus 50% of BI7D
 Function of: BI_FMA7, Current Value
 Limit Type: Minimum Interp.: Linear

FLOW (cfs)	Release (cfs)
0.0	10000.0
10000.0	10000.0
22000.0	16000.0

MinRel_BI

Operates Release From: Jim Woodruff
 Rule Name: MinRel_BI
 Function of: BI_FMA7, Current Value
 Limit Type: Minimum Interp.: Linear

FLOW (cfs)	Release (cfs)
0.0	0.0
9999999.0	9999999.0

MinRel_5050

Operates Release From: Jim Woodruff
 Rule Name: MinRel_5050
 Function of: Date
 Limit Type: Minimum Interp.: Linear

Date	Release (cfs)
01Jan	5050.0

ELSE IF Conditional Non Spawning (Jun - Nov) Description: Seasons Code = 2

Value1	Value2
Seasons	= 2

ELSE IF Conditional BI7D GE 22,000

Value 1: Time Series BI_FMA7, Current Value
 Operator: >=
 Value 2: Constant 22000

ELSE IF Conditional BI7D GE 10,000

Value 1: Time Series BI_FMA7, Current Value
 Operator: >=
 Value 2: Constant 10000

ELSE IF Conditional BI7D GE 5,000

Value 1: Time Series BI_FMA7, Current Value
 Operator: >=
 Value 2: Constant 5000

ELSE Conditional BI7D LT 5,000

ELSE Conditional Winter (Dec - Feb) Description: Seasons Code = 3

Figure K.46 ESA (Part 4 of 4): Seasons – Part 2 of 2 – Check for “Non Spawning (Jun-Nov)”

The screenshot displays a logic tree for **Ramp_Rate_DO4-1** on the left, with detailed views of its components on the right. The logic tree includes nested IF statements for **Hold_RR** and **RIOP-Falling Ramp Rate PA2**, leading to **BI-Falling Ramp Rate**.

RIOP-Falling Ramp Rate PA2 configuration:

- Operates Release From: Jim Woodruff
- Release Rate of Change Limit: RIOP-Falling Ramp Rate PA2
- Description: Ramp Rate data from 'Spreadsheet' Revised_ramping_rate.xls
- Function Of: Release
- Type: Decreasing
- Interpolate: Linear

Release (cfs)	Rate Change (cfs/hr)
1000.0	6.417
2000.0	6.792
3000.0	7.167
4000.0	7.542
5000.0	7.908
6000.0	8.311
7000.0	8.713
8000.0	9.115
9000.0	9.533
10000.0	19.167
11000.0	27.52

BI-Falling Ramp Rate configuration:

- Operates Release From: Jim Woodruff
- Rule Name: BI-Falling Ramp Rate
- Function of: BIFallRate, Current Value
- Limit Type: Minimum
- Interp.: Linear

Flow-Diff (cfs)	Release (cfs)
0.0	0.0
30000.0	30000.0

IF Conditional: Hold_RR=1

Type	Name	Description
IF	Hold_RR=1	
ELSE	Hold_RR=0	

IF Conditional: Hold_RR=1 (Value Configuration)

Value1	Value2
Hold_RR	1

Logical Operator: =

IF Conditional: Release LE 30000

Type	Name	Description
IF	Release LE 30000	

IF Conditional: Release LE 30000 (Value Configuration)

Value1	Value2
Jim Woodruff-Pool:Outflow	30000

Logical Operator: <=

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.

The image shows a software interface for configuring rules. On the left is a tree view with three items: 'Sturgeon Spawning' (folder icon), 'IF (Mar thru May)' (arrow icon), and 'MinRel_forSturgeon' (pink square icon). Dashed arrows point from these items to three configuration windows.

The top window is titled 'Operates Release From: Jim Woodruff'. It has a 'Name' field with 'Sturgeon Spawning' and a 'Description' field. Below is a table:

Type	Name	Description
IF	Mar thru May	

The middle window is also titled 'Operates Release From: Jim Woodruff'. It has an 'IF Conditional' field with 'Mar thru May' and a 'Description' field. Below is a table with two columns: 'Value1' and 'Value2'.

Value1	Value2
Seasons	= 1

Buttons on the right include 'Add Cond.', 'Del. Cond.', 'Move Up', 'Move Down', and 'Evaluate'. Below the table are 'Logical Operator' and 'Operator' dropdowns, and 'Value 1' and 'Value 2' fields with 'Pick Value' buttons.

The bottom window is titled 'Operates Release From: Jim Woodruff'. It has a 'Rule Name' field with 'MinRel_forSturgeon' and a 'Description' field. The 'Function of:' field contains 'MinStage_Chattahoochee, Current Value' with a 'Define...' button. The 'Limit Type' is 'Minimum' and 'Interp.' is 'Linear'. Below is a table:

Elev-Min (ft)	Release (cfs)
35.5	0.0
37.0	1999.0
38.0	3500.0
38.5	4180.0
39.0	4900.0
39.5	5670.0
40.0	6480.0
40.5	7320.0
41.0	8200.0
41.5	9120.0
42.0	10100.0
42.5	11000.0
43.0	12100.0
43.5	13100.0
44.0	14200.0
44.5	15300.0
45.0	16400.0

To the right of the table is a graph with 'Elev-Min (ft)' on the x-axis (35 to 55) and 'Release (cfs)' on the y-axis (0 to 50,000). The graph shows a blue curve that increases exponentially. Below the graph are several checkboxes: 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

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:

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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).

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The screenshot displays the configuration for a rule named "RiverStage_FallingLimit" within a software interface. The interface includes a tree view on the left and several configuration windows.

Tree View:

- Fish Spawning_Apalachicola River
 - IF ((01Apr-01Jun) & (flow.LE.30000))
 - RiverStage_FallingLimit

Operates Release From: Jim Woodruff (Top Window):

- Name: Fish Spawning_Apalachicola
- Description: Operational consideration for fish spawning
- IF Conditional: (01Apr-01Jun) & (flow.LE.30000)
- Description: Fish spawning period: 01April - 01June

Operates Release From: Jim Woodruff (Middle Window):

- IF Conditional: (01Apr-01Jun) & (flow.LE.30000)
- Description: Fish spawning period: 01April - 01June

	Value1		Value2
	(
	Current Time Step	>=	01Apr
AND	Current Time Step	<=	01Jun
)		
AND	Jim Woodruff-Pool:Outflow	<=	30000

RiverStage_FallingLimit Rule Configuration:

- Release Rate of Change Limit: RiverStage_FallingLimit
- Description: River stage ramping down of 0.5 foot per day or less. The relation between release and flow rate change were calculated in the spreadsheet, called "FishSpawning_ApalachicolaRiver.xls"
- Function Of: Release
- Type: Decreasing
- Interpolate: Linear

Release (cfs)	Rate Change (cfs/hr)
1000.0	28.4
2000.0	28.2
3000.0	28.5
4000.0	28.2
5000.0	30.6
6000.0	33.0
7000.0	34.5
8000.0	36.0
9000.0	38.5
10000.0	40.5
12000.0	45.4
14000.0	45.0
16000.0	45.7
18000.0	47.4
20000.0	50.2
24000.0	53.7
28000.0	58.0
32000.0	59.0
36000.0	61.7
40000.0	65.0

Graph: A line graph showing Rate Change (cfs/hr) on the y-axis (ranging from 25 to 70) versus Release (cfs) on the x-axis (ranging from 0 to 30,000). The curve shows a generally increasing trend with some fluctuations, starting around 28 cfs/hr at 1,000 cfs release and reaching 65 cfs/hr at 40,000 cfs release.

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:

```

5 # State variable: JimWoodruff_Elev_State
6 # Code =0: Pool is rising
7 #     =1: The first day of the fish spawning
8 #     =2: The pool has dropped within 0.3 ft from the base elevation
9 #     =3: The pool has dropped within 0.3-0.4 ft from the base elevation
10 #    =4: The pool has dropped within 0.4-0.45 ft from the base elevation
11 #    =5: The pool has dropped within 0.45-0.49 ft from the base elevation
12 #    =6: The pool has dropped within 0.49-0.50 ft from the base elevation
13 #    =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

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dropping pool, the following limits of pool elevation changes within 24 hours are applied:

<u>Lake State</u>	<u>Cumulative Drop from Base Elevation (ft)</u>	<u>Limit of Pool Draw-down (ft)</u>
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

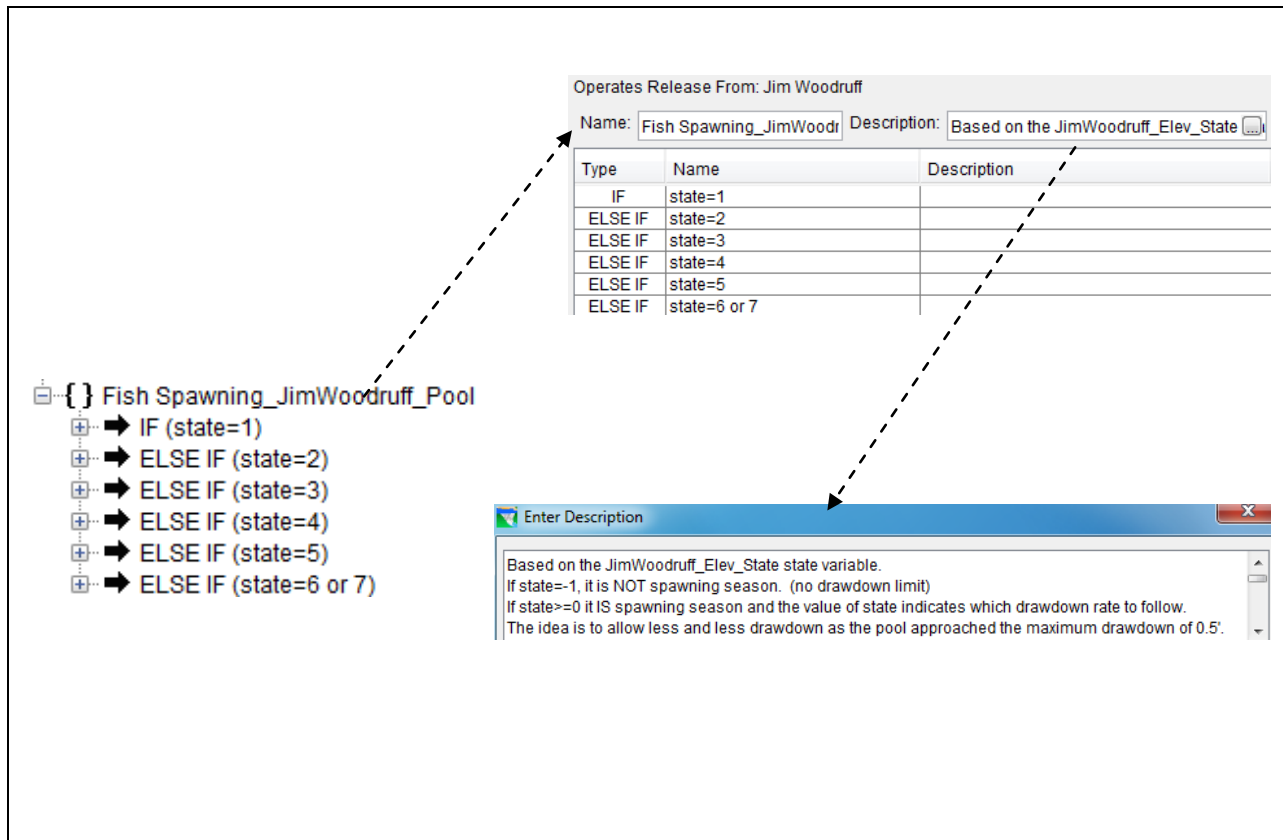


Figure K.50 Fish Spawning at Jim Woodruff -- “Conditional Blocks” at Jim Woodruff

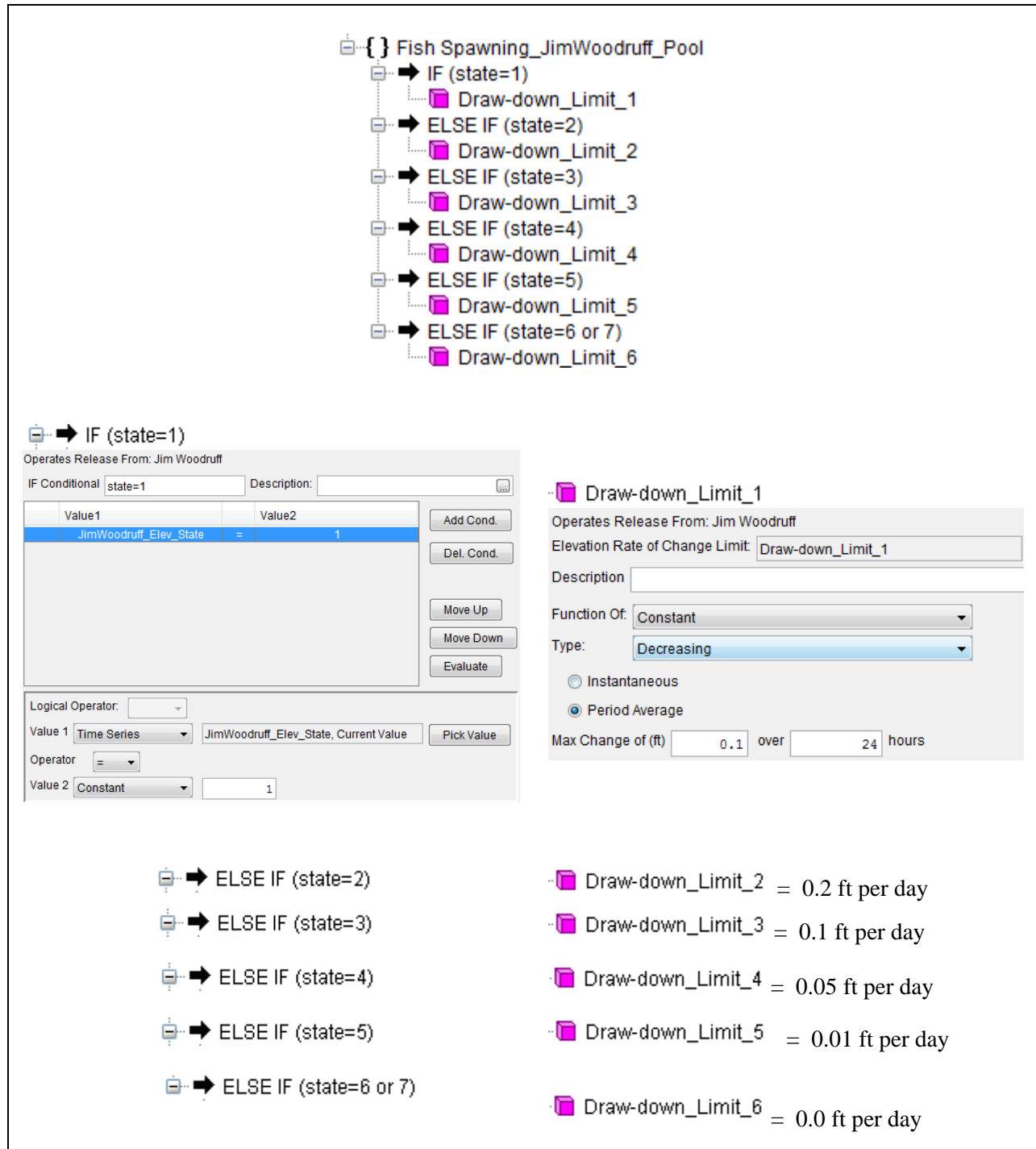


Figure K.51 Fish Spawning at Jim Woodruff -- “IF-Blocks” and “Rules” at Jim Woodruff

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).

{ } Release Inflow up to Minimum Reqmt

- Operating Inactive
- Release Inflow up to Minimum Reqmt**
 - IF (EDO)
 - MinInflow_to4550
 - ELSE (not EDO)
 - MinInflow_to5050

Operates Release From: Jim Woodruff

Name: Description:

Type	Name	Description
IF	EDO	
ELSE	not EDO	

Operates Release From: Jim Woodruff

IF Conditional: Description:

Value1		Value2
EDO_Flow	=	1

Logical Operator:

Value 1:

Operator:

Value 2:

MinInflow_to4550

Operates Release From: Jim Woodruff

Rule Name: Description:

Function of:

Limit Type: Interp.:

Flow (cfs)	Release (cfs)
0.0	0.0
4550.0	4550.0
1000000.0	4550.0

MinInflow_to5050

Operates Release From: Jim Woodruff

Rule Name: Description:

Function of:

Limit Type: Interp.:

Flow (cfs)	Release (cfs)
0.0	0.0
5050.0	5050.0
1000000.0	5050.0

Figure K.52 Release inflow up to Minimum Reqmt-- “IF-Blocks” and “Rules” at Jim Woodruff

K-63

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
<i>Glades</i>	NO-Action	No
Buford	NO-Action	Yes
Morgan Falls	NO-Action	Yes
<i>Bear Creek</i>	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.

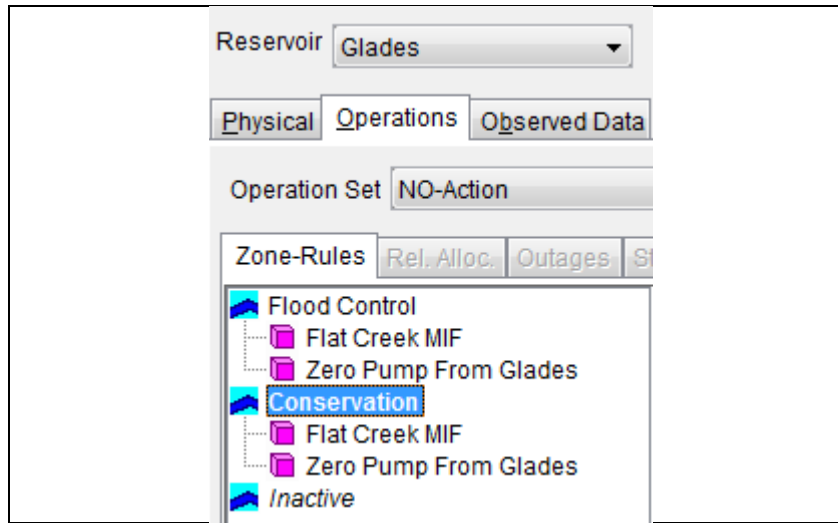


Figure K.53 Rule Set for Glades NO-Action Operation Set

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.

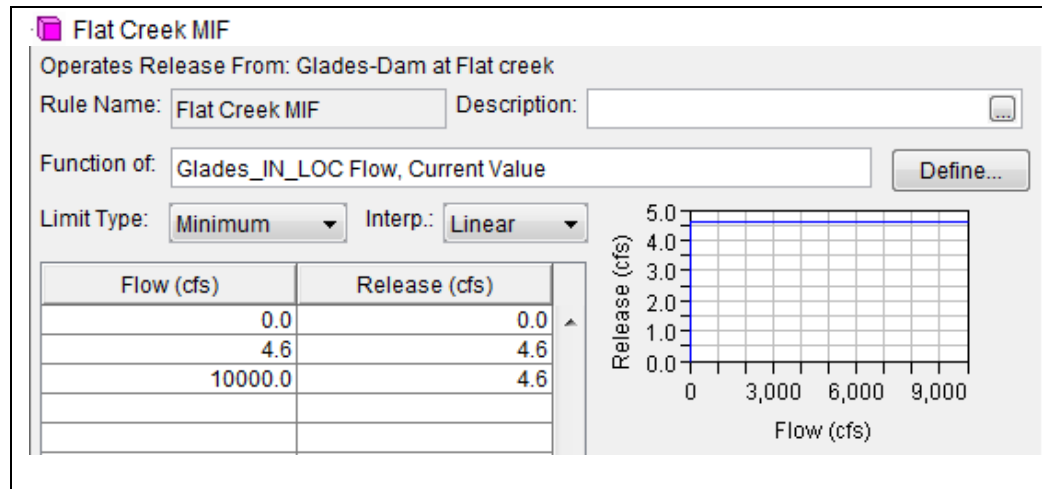


Figure K.54 Glades Reservoir – Flat Creek MIF rule

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.

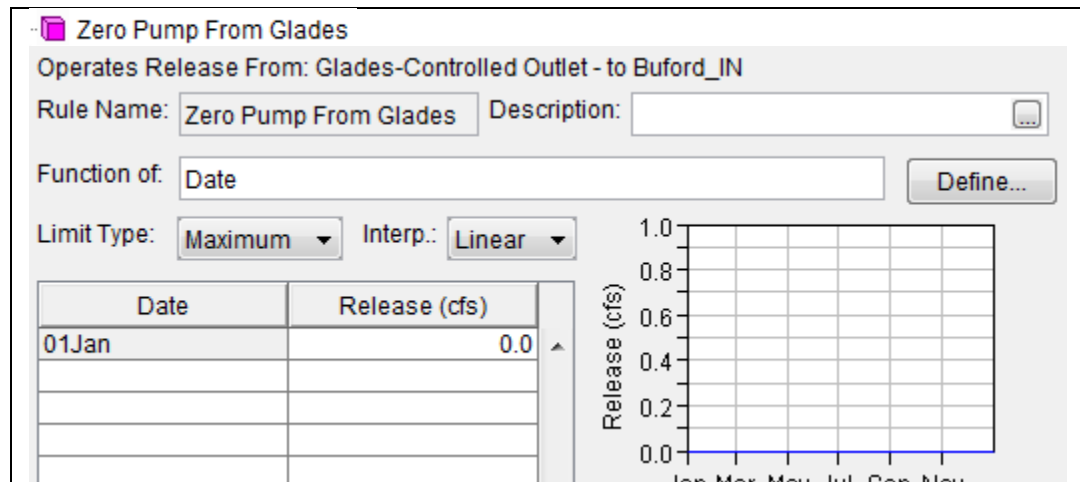


Figure K.55 Glades Reservoir – Zero Pump From Glades rule

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.

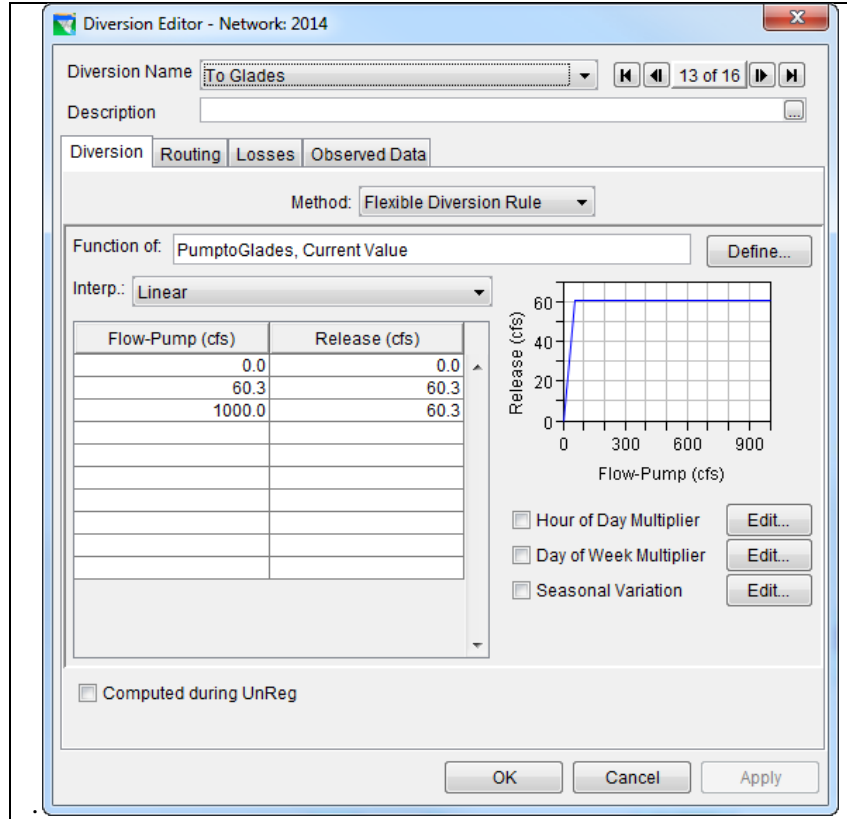


Figure K.56 Diversion Editor – Network 2014: To Glades

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.

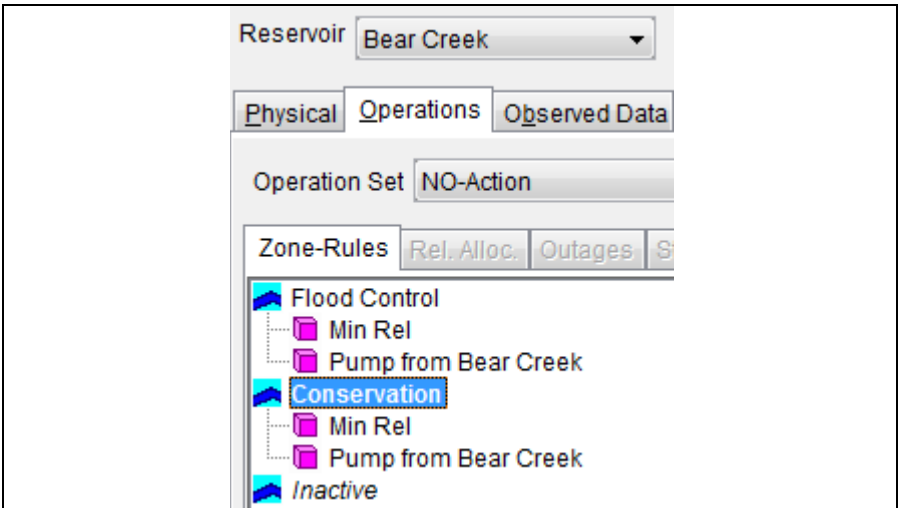


Figure K.57 Rule Set for Bear Creek NO-Action Operation Set

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.

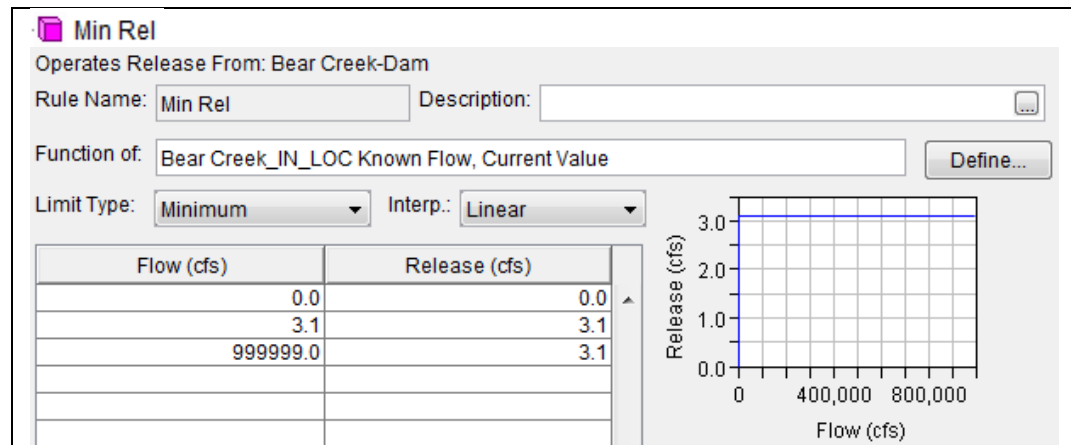


Figure K.58 Bear Creek Reservoir –*Min Rel* rule

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).

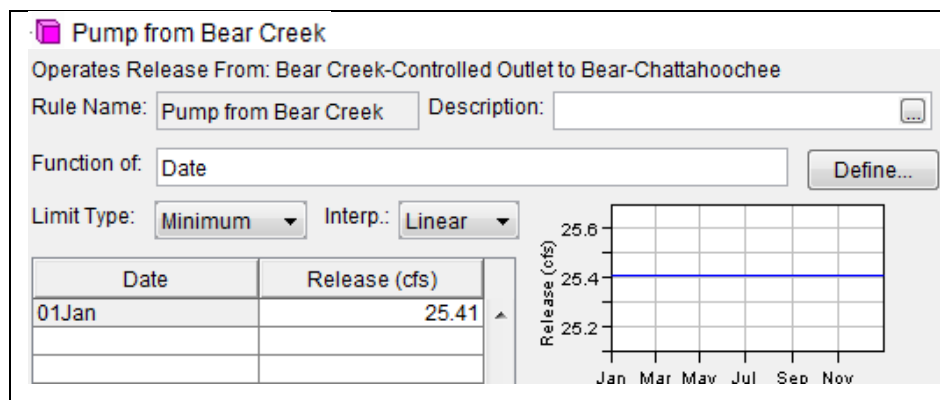


Figure K.59 Bear Creek Reservoir –*Pump From Bear Creek* rule

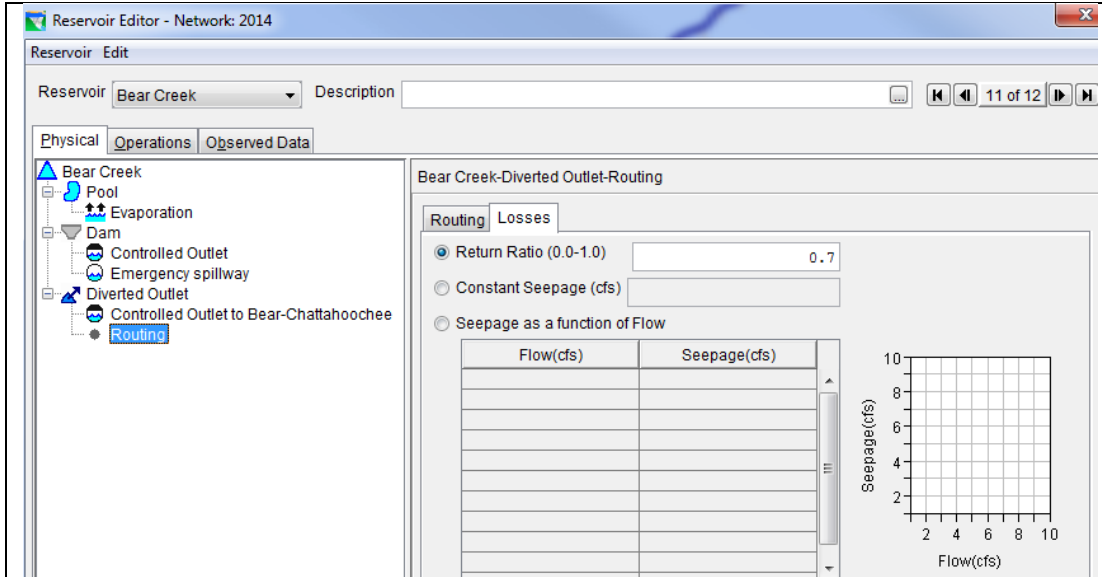


Figure K.60 Bear Creek-Diverted Outlet-Routing

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.

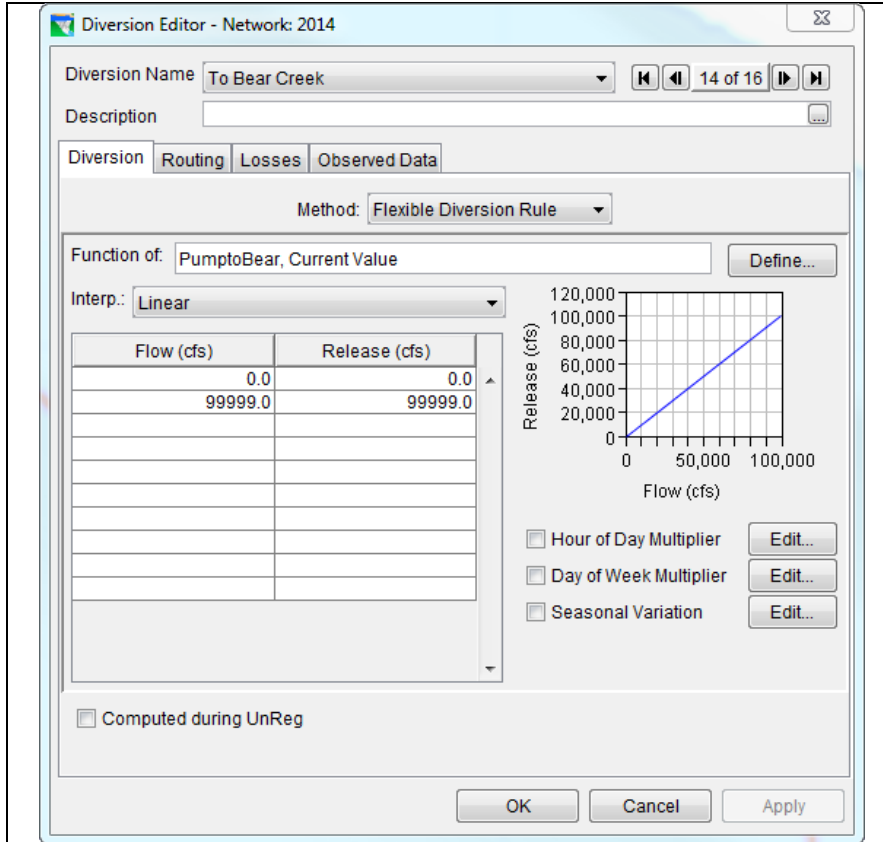


Figure K.61 Diversion Editor-To Bear Creek

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
<i>Buford</i>	Silver	No
Morgan Falls	Flow-thru	Yes
Bear Creek	NO-Action	Yes
<i>West Point</i>	Silver	No
Bartletts Ferry	Flow-thru	Yes
Goat Rock	Flow-thru	Yes
Oliver	Flow-thru	Yes
North Highlands	Flow-thru	Yes
<i>Walter F George</i>	Silver	No
George Andrews	Flow-thru	Yes
<i>Jim Woodruff</i>	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
<i>Zone 2</i>	1066	1068				1068		
<i>Zone 3</i>	1063	1066.5				1066.5		
<i>Zone 4</i>	1060		1065			1065		
Operating Inactive	1035							

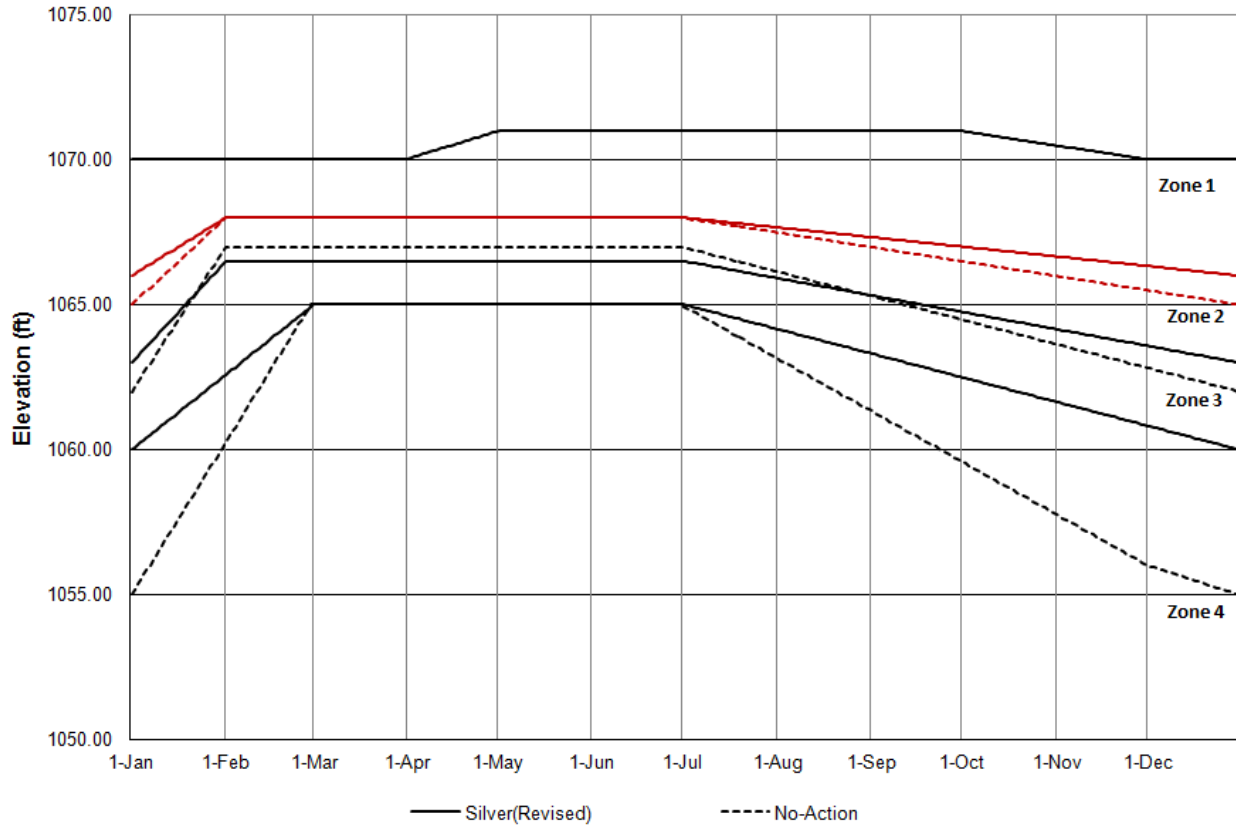


Figure K.62 Comparison of NO-Action and Revised Action Zones at Buford

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.

power Gen fn of drought_FC (within Flood Control zone)

Operation Set Silver Description This Ops is set for:

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Top of Dam
 Flood Control
 MaxCC
 Max@Norcross_11000
 Max@Atlanta_13200
 Min_600_Small Unit
 power Gen fn of drought_FC
 IF (DO4-1 EQ 1)
 2HrsGen_FC
 ELSE (RIOP)
 3HrsGen_FC

Name: power Gen fn of drought_FC Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant
 IF Conditional DO4-1 EQ 1 Description:

Value1	Value2
Drought_Ops_4_1	= 1

Operates Release From: Buford-Power Plant
 ELSE Conditional RIOP

Operates Release From: Buford-Power Plant
 Hydropower - Power Guide Curve Rule: 2HrsGen_FC
 Description: 2 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	8.3
100.0	8.3

Operates Release From: Buford-Power Plant
 Hydropower - Power Guide Curve Rule: 3HrsGen_FC
 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

Figure K.63 Silver Operation Set Hydropower Rules for Flood Control Zone

Appendix K – Development of Alternatives

power Gen fn of drought_Z1 (within Conservation zone)

Operation Set: Silver Description: This Ops is set for:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Conservation

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z1
 - IF (DO4-1 EQ 1)
 - 2HrsGen_Z1
 - ELSE (RIOP)
 - 3HrsGen_Z1

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z1

Description: 2 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	8.3
100.0	8.3

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 3HrsGen_Z1

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

Figure K.64 Silver Operation Set Hydropower Rules for Conservation zone

power Gen fn of drought_Z2 (within Zone 2)

Operation Set: Silver Description: This Ops is set for.

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Zone 2

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z2
 - IF (DO4-1 EQ 1)
 - 1HrGen_Z2
 - ELSE (RIOP)
 - 2HrsGen_Z2

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 1HrGen_Z2

Description: 1 hour 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	4.16
100.0	4.16

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z2

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 K.65 Silver Operation Set Hydropower Rules for Zone 2

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power Gen fn of drought_Z3 (within Zone 3)

Operation Set: Silver Description: This Ops is set for:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Zone 3

- MaxCC
- Max@Norcross_11000
- Max@Atlanta_13200
- Min_600_Small Unit
- power Gen fn of drought_Z3
 - IF (DO4-1 EQ 1)
 - 1HrGen_Z3
 - ELSE (RIOP)
 - 2HrsGen_Z3

Name: power Gen fn of drought_Z Description:

Type	Name	Description
IF	DO4-1 EQ 1	
ELSE	RIOP	

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 1HrGen_Z3

Description: 1 hour generation at full capacity

Zone at Top of Power Pool: Zone 3

Zone at Bottom of Power Pool: Zone 4

% Power Storage	Plant Factor (%)
0.0	4.16
100.0	4.16

Operates Release From: Buford-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen_Z3

Description: 2 hours of generation at full capacity

Zone at Top of Power Pool: Zone 3

Zone at Bottom of Power Pool: Zone 4

% Power Storage	Plant Factor (%)
0.0	8.3
100.0	8.3

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.

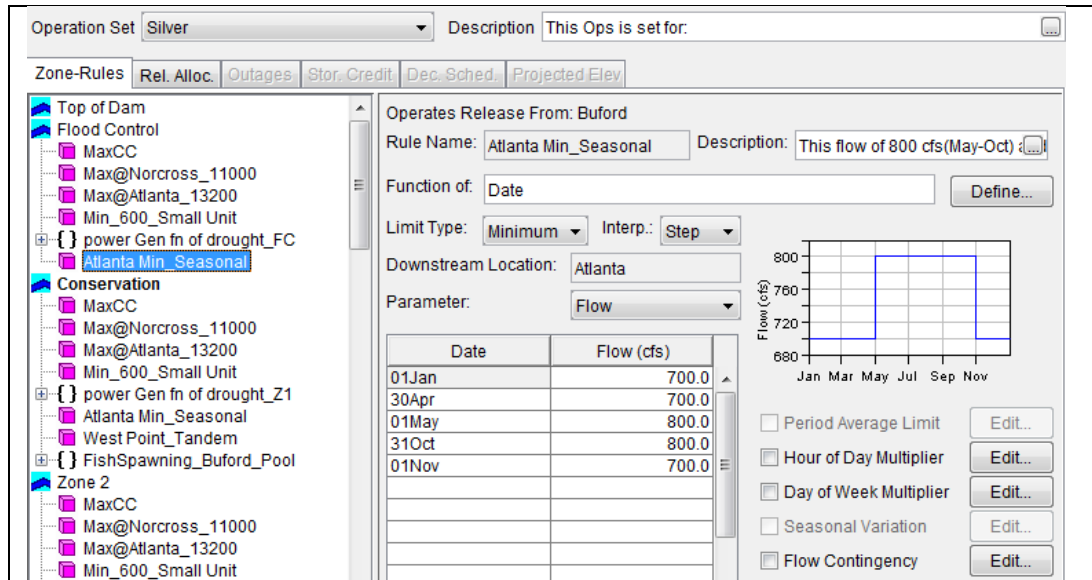


Figure K.67 Silver Operation Set Seasonal Minimum Flow rule at Peach Tree Creek

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									

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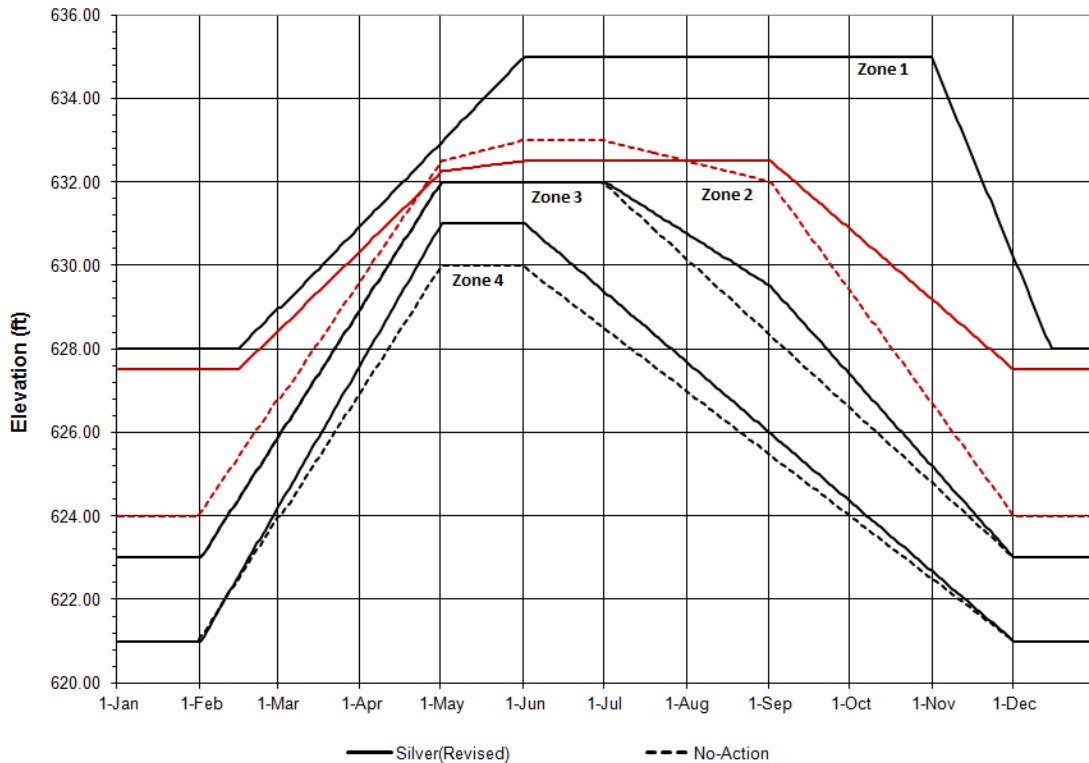


Figure K.68 Comparison of NO-Action and Revised Action Zones at West Point

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						

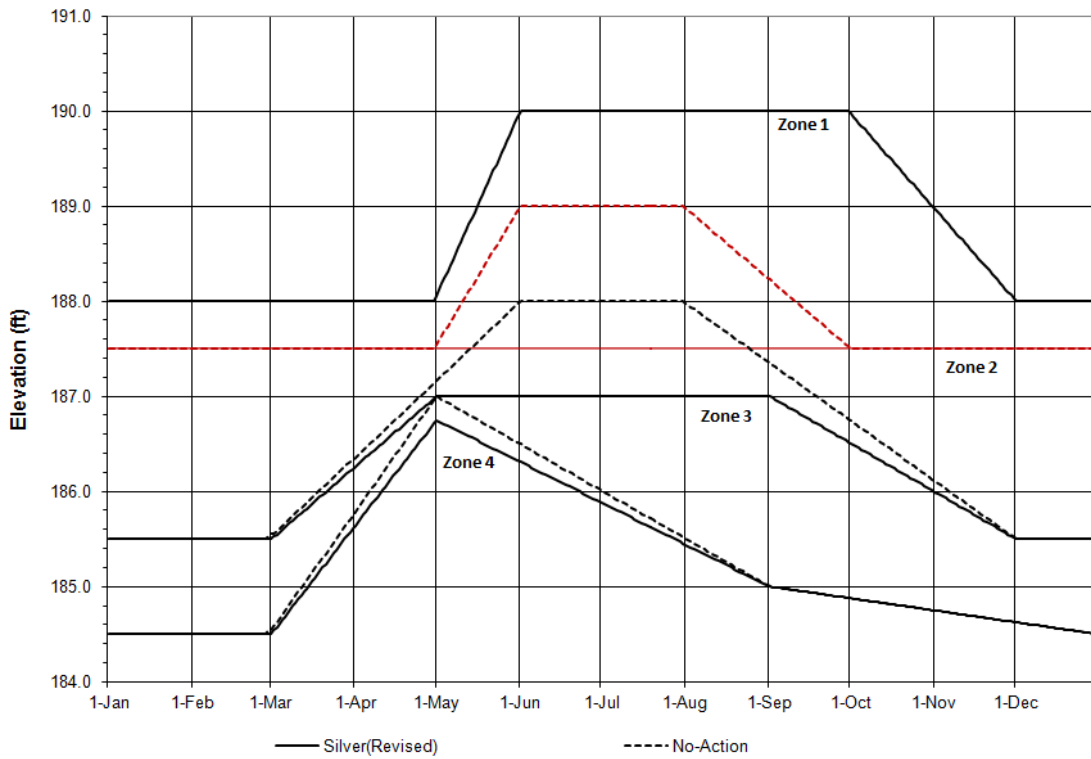


Figure K.69 Comparison of NO-Action and Revised Action Zones at Walter F. George

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.

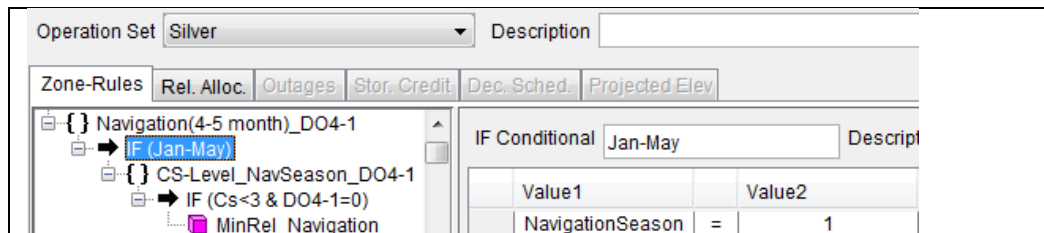


Figure K.70 Conditional Blocks for *Navigation(4-5 month)_DO4-1* Rule

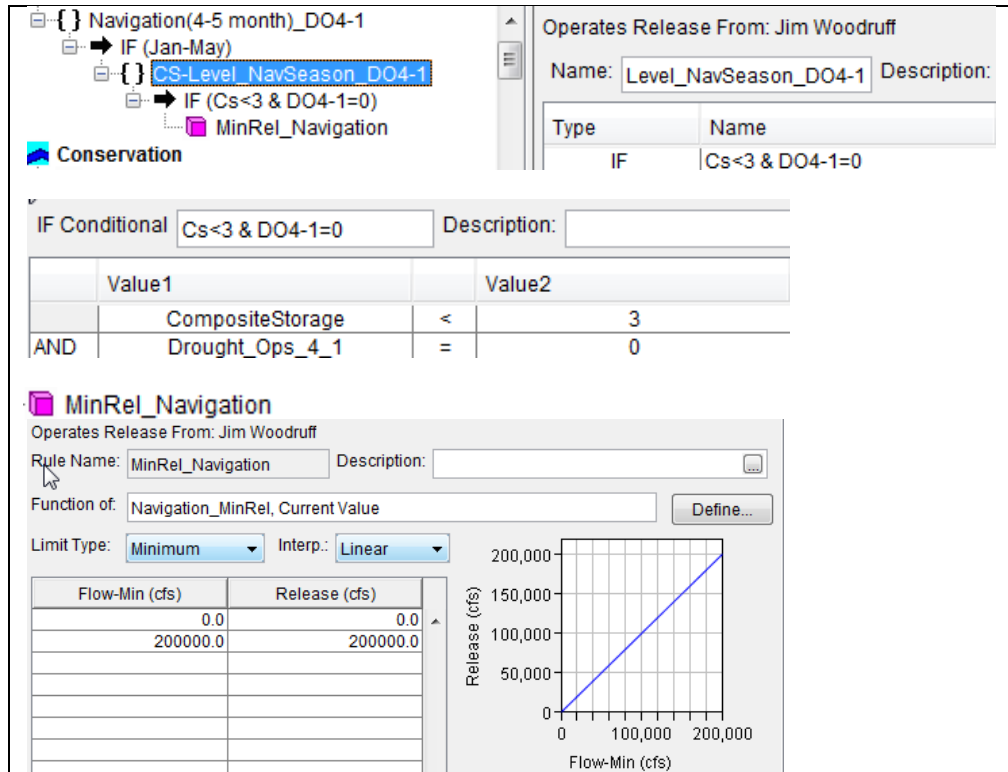


Figure K.71 Release Rules for *Navigation(4-5)month_DO4-1* Rule

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 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. 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.

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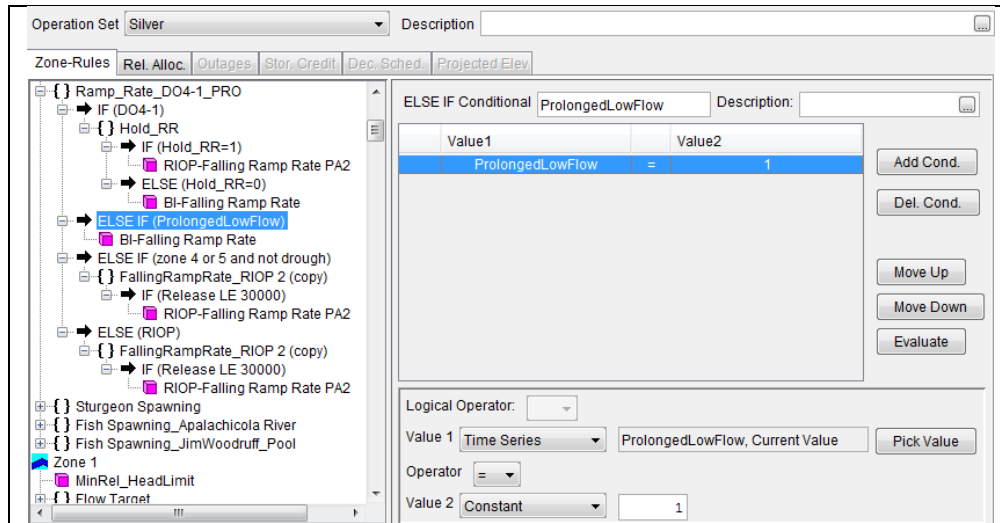


Figure K.72 Conditional Block for *Ramp_Rate_DO4-1_PRO* Rule

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
<i>Jim Woodruff</i>	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).

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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
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.

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The screenshot displays the configuration for the 'Tri-Rivers' alternative. On the left, a tree view shows the following structure:

- Tri-Rivers
 - IF (DO4-1)
 - ELSE IF (Zone 4 or 5 and not DO)
 - ELSE (RIOP)

Dashed arrows indicate the configuration panels for each condition:

- IF Conditional DO4-1:**

Value1	Value2
Drought_Ops_4_1	= 1

Logical Operator: [Dropdown]
 Value 1: Time Series, Drought_Ops_4_1, Current Value
 Operator: =
 Value 2: Constant, 1
- ELSE IF Conditional Zone 4 or 5 and not DO:**

Value1	Value2
CompositeStorage	>= 4

Logical Operator: [Dropdown]
 Value 1: Time Series, CompositeStorage, Current Value
 Operator: >=
 Value 2: Constant, 4
- ELSE Conditional RIOP:** (Currently empty)

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)”

The screenshot displays a software interface for configuring drought operations. On the left, a logic tree for 'Tri-Rivers' shows a sequence of conditions: 'IF (D04-1)' leading to 'EDO', which then branches into 'IF (EDO)' (with 'MinRel_4550') and 'ELSE (Not EDO)' (with 'MinRel_5050'). Below this, another 'EDO' condition is shown with similar branches. Dashed arrows connect these logic elements to the configuration panels on the right.

The top-right panel is for 'MinRel_4550'. It shows a table with columns 'Type', 'Name', and 'Description'. The 'Type' column has 'IF' and 'ELSE', with 'Name' values 'EDO' and 'Not EDO' respectively. Below this, the 'Operates Release From: Jim Woodruff' section includes 'Rule Name: MinRel_4550' and 'Description:'. The 'Function of: Date' is set to 'Date'. The 'Limit Type' is 'Minimum' and 'Interp.' is 'Linear'. A table shows 'Date' as '01Jan' and 'Release (cfs)' as '4550.0'. A graph plots 'Release (cfs)' from 4,500 to 4,600 against months 'Jan' through 'Nov', with a horizontal line at 4,550.0. Additional options include 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

The bottom-right panel is for 'MinRel_5050'. It shows a similar configuration with 'Rule Name: MinRel_5050' and 'Description: This flow of 5050 cfs represents the r'. The 'Function of: Date' is 'Date'. The 'Limit Type' is 'Minimum' and 'Interp.' is 'Linear'. The table shows 'Date' as '01Jan' and 'Release (cfs)' as '5050.0'. The graph plots 'Release (cfs)' from 4,960 to 5,120 against months 'Jan' through 'Nov', with a horizontal line at 5,050.0. The same additional options are present.

The bottom-left panel shows an 'IF Conditional' configuration for 'EDO'. It includes a table with 'Value1' as 'EDO_Flow' and 'Value2' as '1'. Below this, the 'Logical Operator' is set to '=', 'Value 1' is 'Time Series' (EDO_Flow, Current Value), and 'Value 2' is 'Constant' (1). Buttons for 'Add Cond.', 'Del. Cond.', 'Move Up', 'Move Down', 'Evaluate', and 'Pick Value' are also visible.

Figure K.74 Tri-Rivers (Part 2 of 6): Drought Operations ,Checking for “EDO” , “MinRel_4550”and Not EDO, “MinRel_5050”

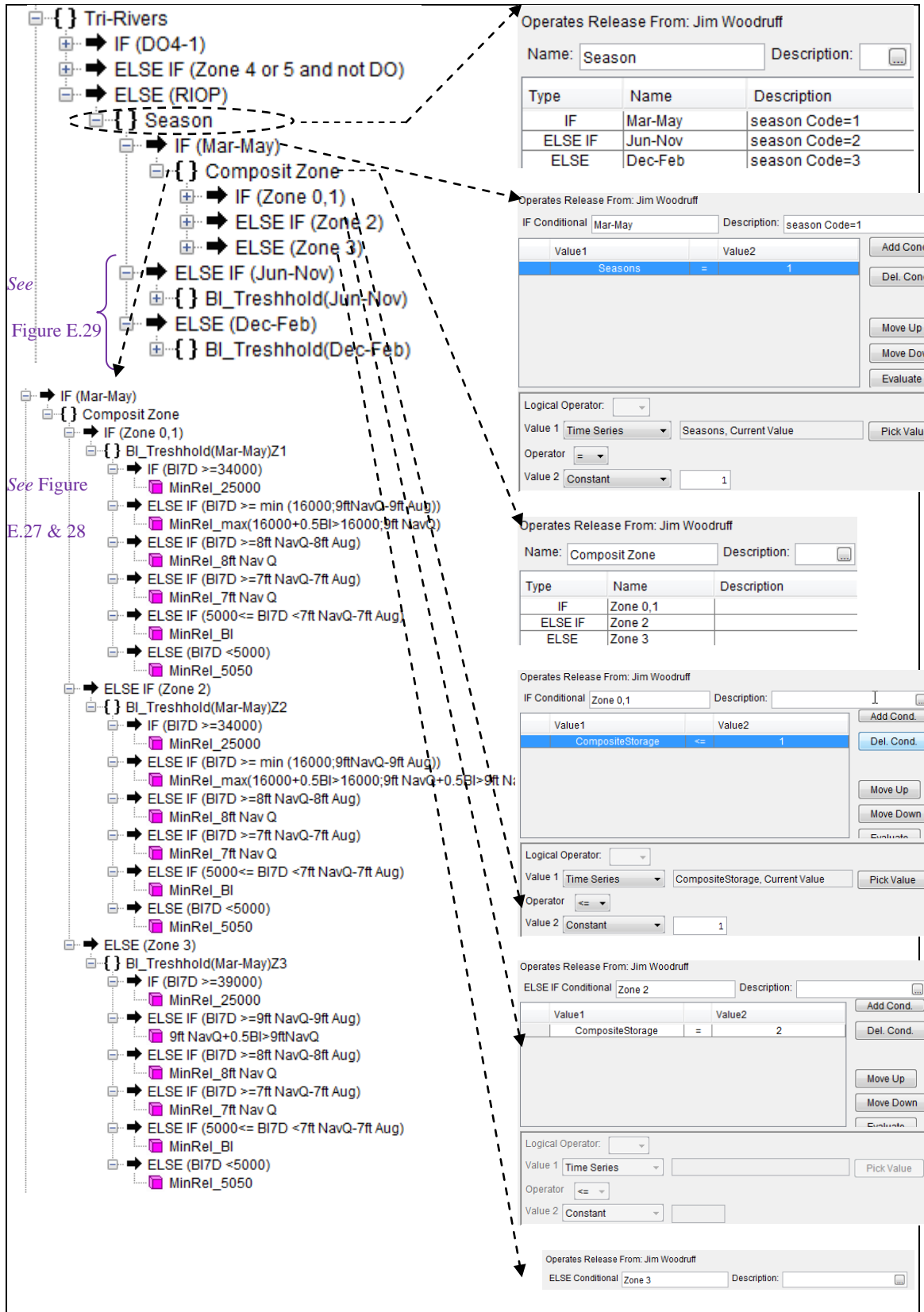


Figure K.75 Tri-Rivers (Part 3 of 6): Season–“Overview” and check for “(Mar-May)” – Part 1 of 3

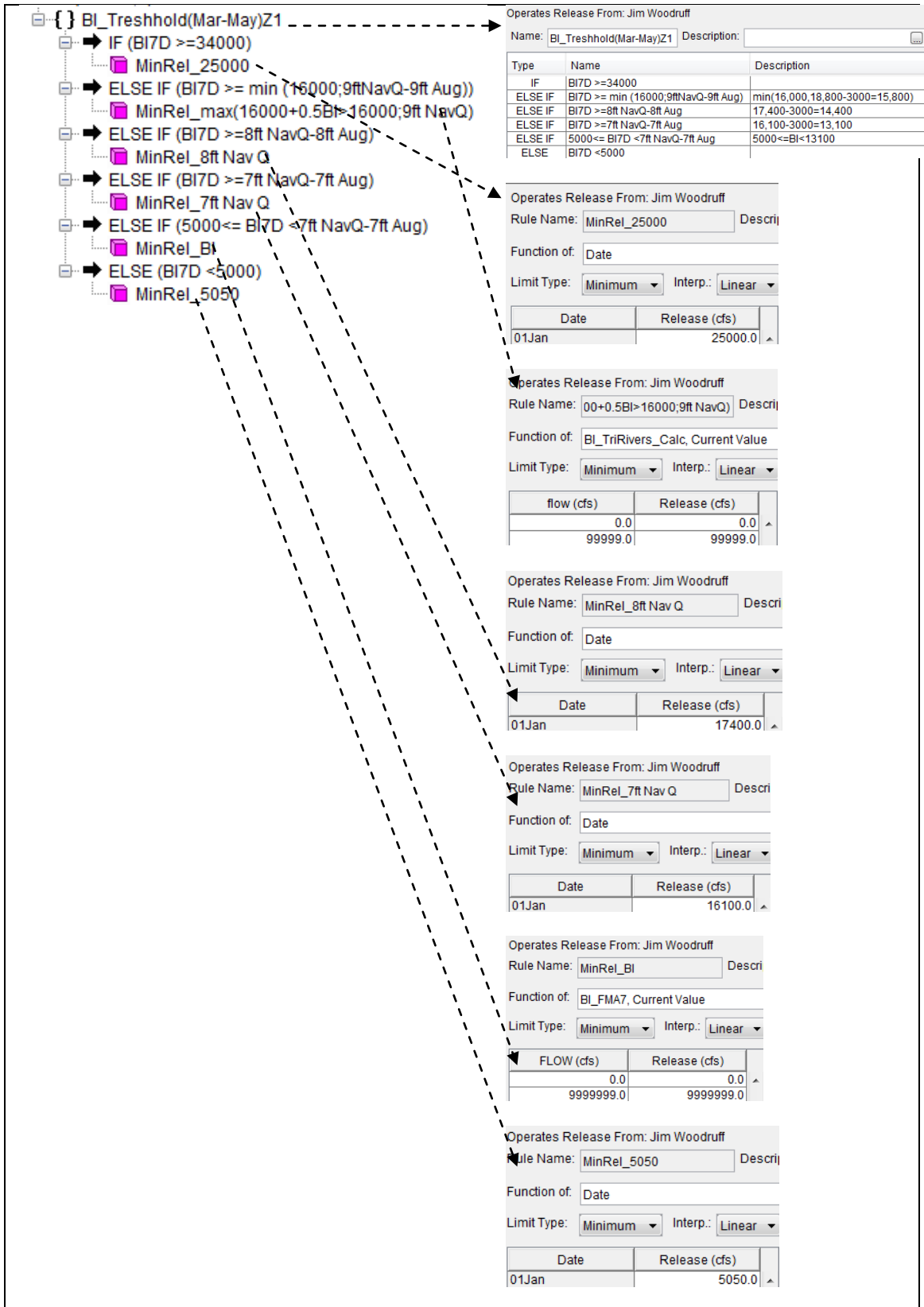


Figure K.76 Tri-Rivers (Part 4 of 6): Season–“Overview” and check for “(Mar-May)” – Part 2 of 3

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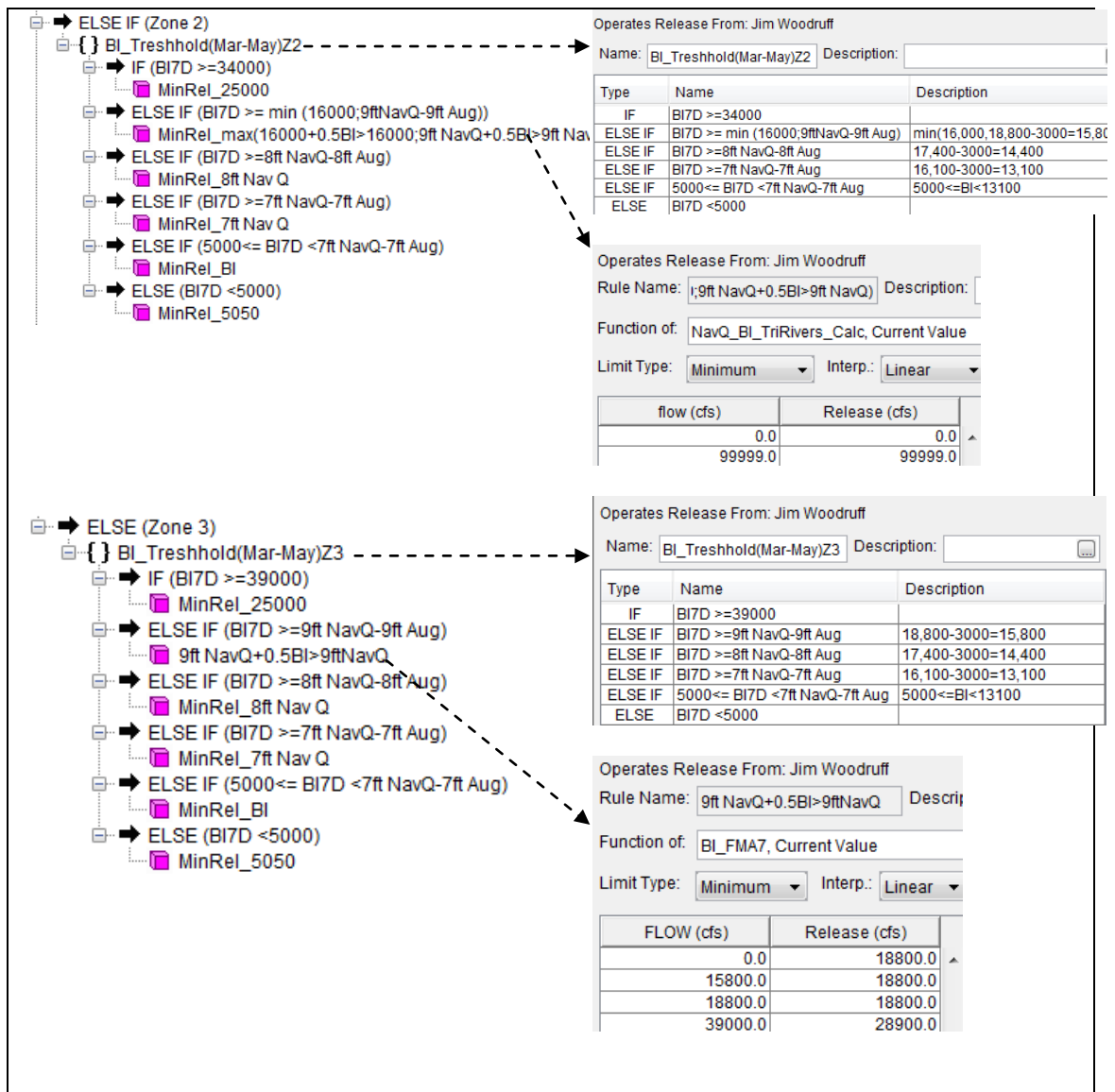


Figure K.77 Tri-Rivers (Part 5 of 6): Season– “Overview” and check for “(Mar-May)” – Part 3 of 3

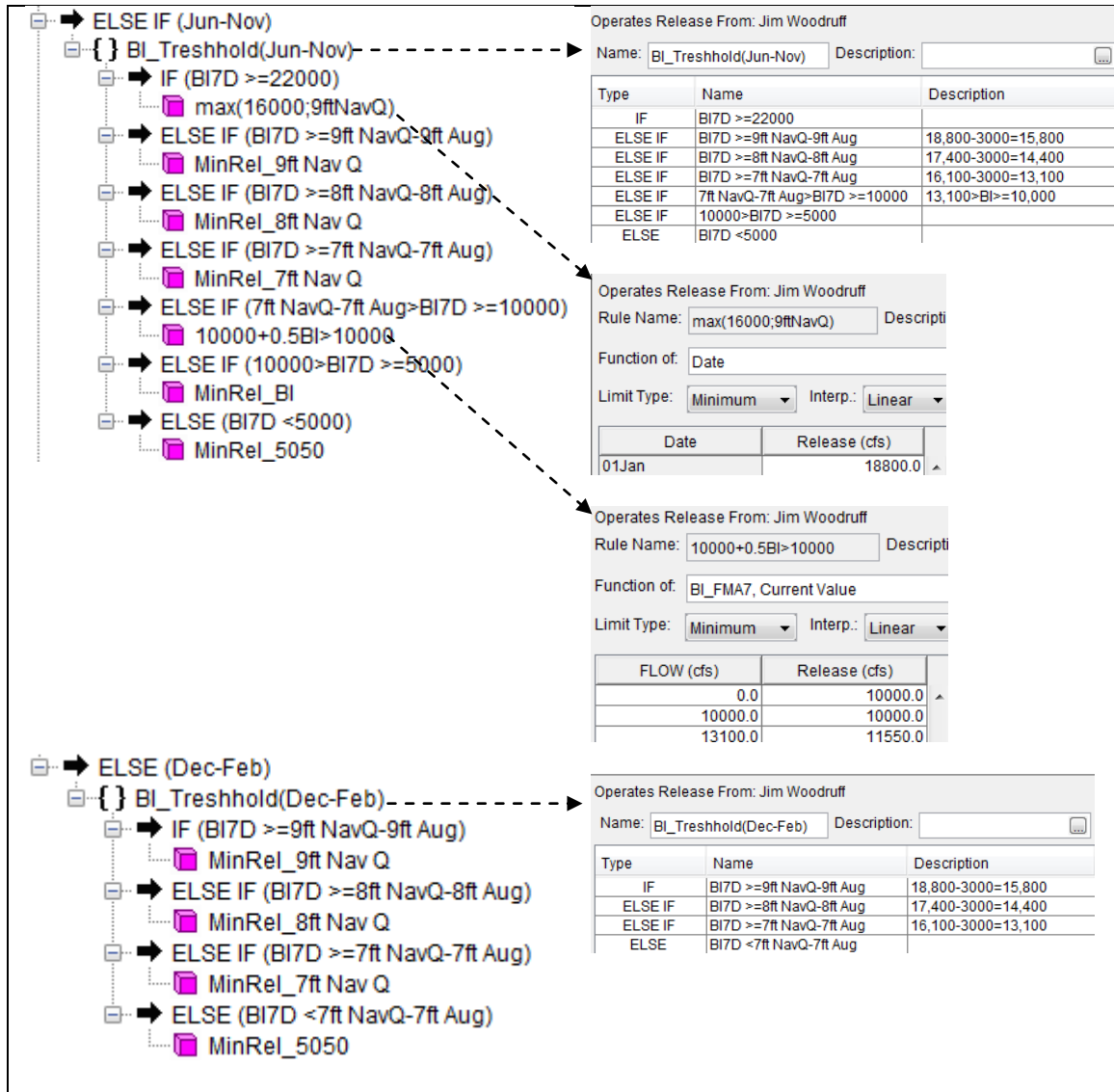


Figure K.78 Tri-Rivers (Part 6 of 6): Season– “Overview” and check for “(Jun-Nov)” and “(Dec-Feb)”

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
<i>Jim Woodruff</i>	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.

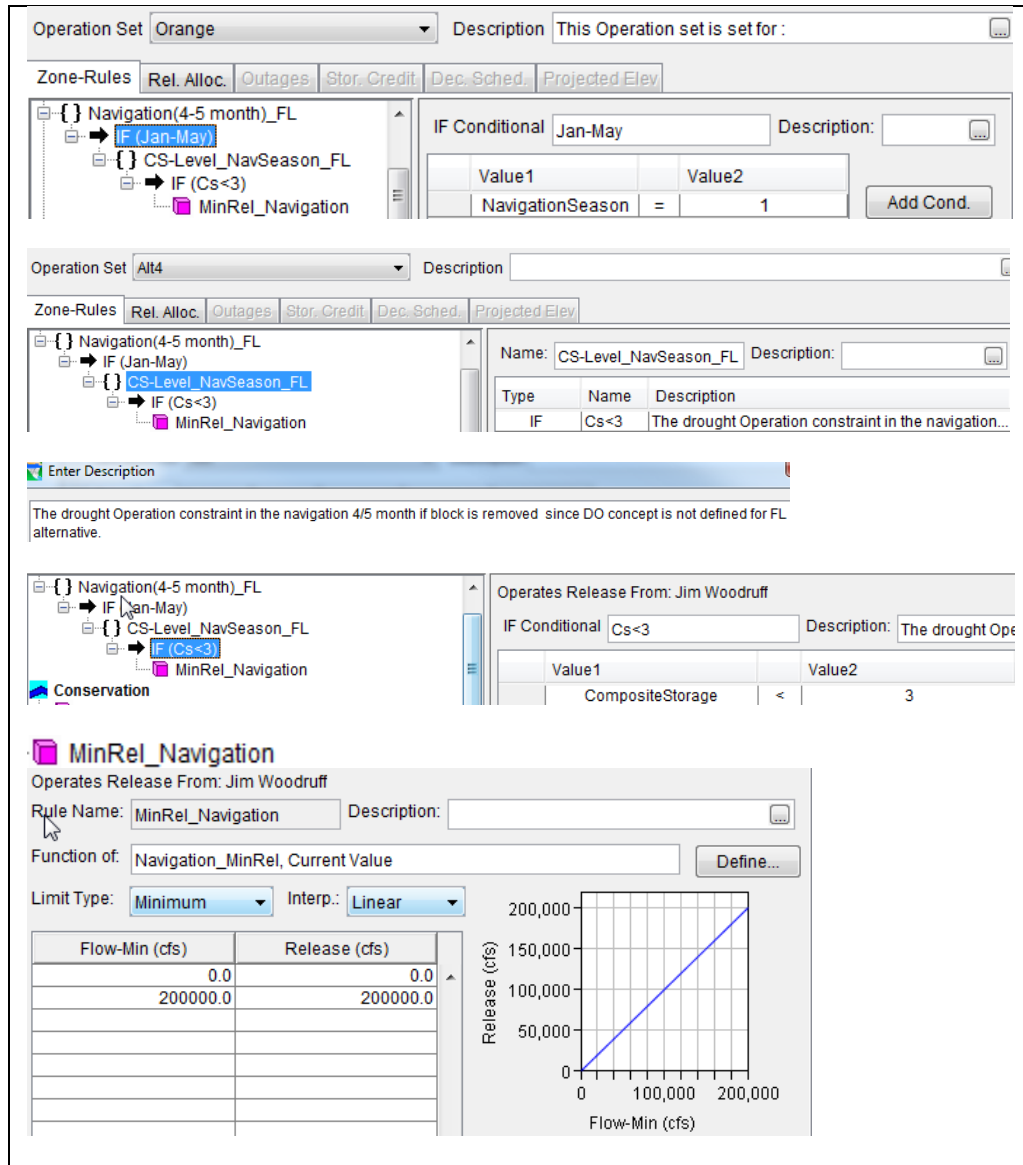


Figure K.79 Release Rules for Navigation (4-5)month_FL

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.

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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

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	<u>Mar-Nov</u> : 50% of any RBI-P7 that exceeds minimum flow <u>Dec-Feb</u> : 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*
<p>*Conditions when 50% of storm pulses are released are under review and will be include at a later time.</p> <p>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)</p>			

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.

Appendix K – Development of Alternatives

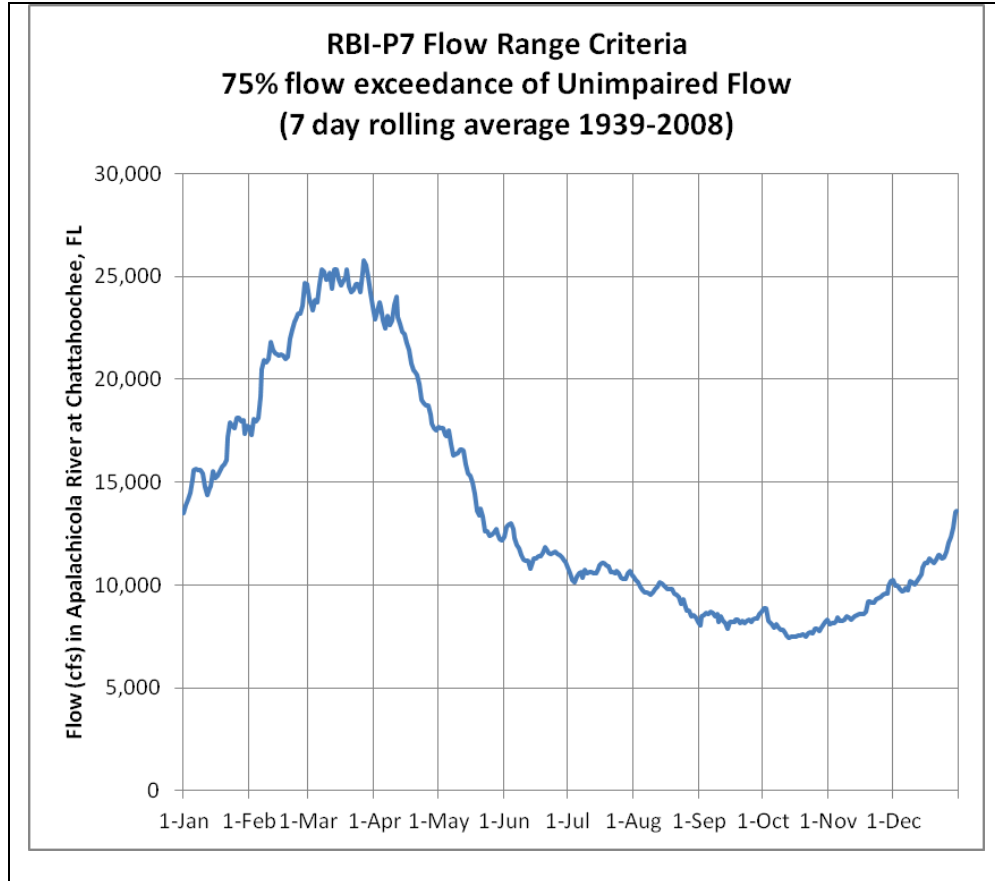


Figure K.80 Florida Flow Target-Flow range criteria

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.

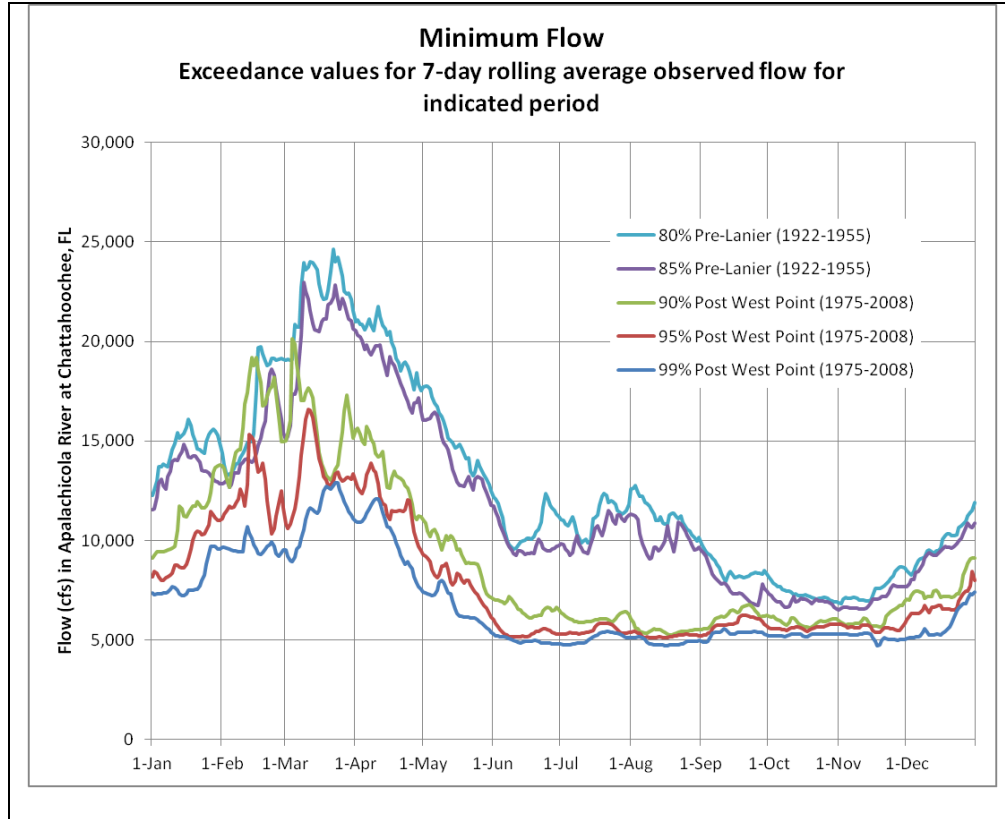


Figure K.81 Florida Flow Target-Daily Minimum Flow

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	

Appendix K – Development of Alternatives

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
<i>Jim Woodruff</i>	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) _D04-1*

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:

$$\text{Basin Inflow} = \text{Chattahoochee River flow} + \text{Lanier change in storage} + \text{West Point change in storage} + \text{WF George change in storage} + \text{Jim Woodruff change in storage}$$

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

Appendix K – Development of Alternatives

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	$\geq 6,500$	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 $Q = \min(10,500, \min(\text{observed moving 30-day flow}))$	Entire or partial BI above SLF, subject to available Storage capacity
		Otherwise if $BI \geq 10,500$	$\geq 10,500$	
		If $BI < 10,500$ and $\geq 5,000$ If $BI < 5,000$	$\geq BI$ $\geq 5,000$	
In sub-period April 16- April 30		Lanier $> 1066'$, and West Point $> 632'$, and Walter F George $> 187'$	Maintain $Q = \min(22,500, \max(10,500, \min(\text{observed March 17-April 15 daily flow})))$	Entire or partial BI above SLF, subject to available Storage capacity
June- Nov	Zone 1,2, and 3	$BI \geq 10476$ & previous seven day's Chattahoochee gage flow < 5100	\geq 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
		$BI \geq 7181$ and < 10476 & previous seven day's Chattahoochee gage flow < 5100	\geq 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	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
Dec-Feb	Zone 1,2, and 3	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Zone 4 Or Drought Ops	NA	$\geq 5,000$	Entire or partial BI above 5,000 subject to available Storage capacity
At all times	Drought Zone	NA	$\geq 4,500$	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:

Appendix K – Development of Alternatives

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	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 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.

Appendix K – Development of Alternatives

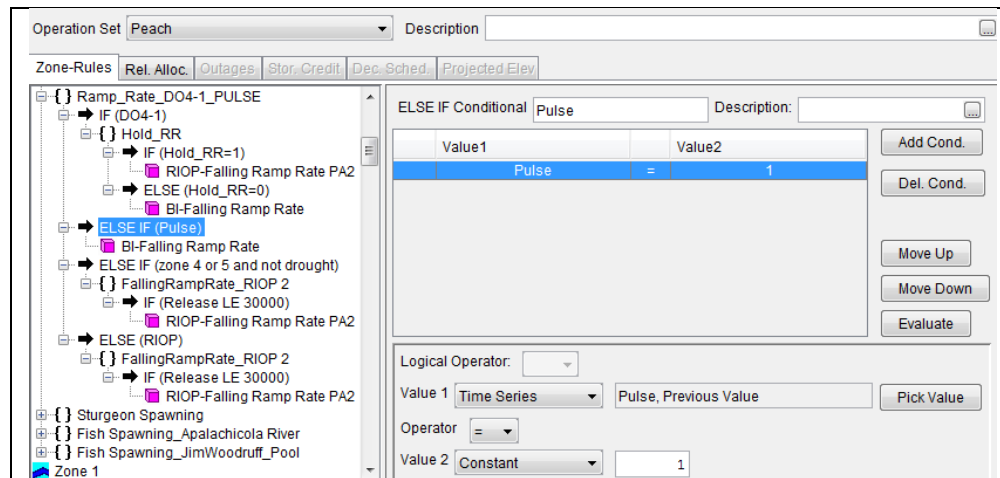


Figure K.82 Conditional Block for Ramp_Rate_DO4-1_PULSE Rule

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
<i>Buford</i>	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
<i>Jim Woodruff</i>	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.

The screenshot shows the configuration of the 'Blue' operation set. The main window displays a tree view of rules under 'Atlanta Min_Alt6'. The rules are:

- IF (Zone 0,1)
- Atlanta Min_FWS_Z1
- ELSE IF (Zone2)
- Atlanta Min_FWS_Z2
- ELSE IF (Zone3)
- Atlanta Min_FWS_Z3
- ELSE (zone 4,5)
- Atlanta Min_FWS_Z4

The 'Name' table lists the rule types and their associated zones:

Type	Name	Description
IF	Zone 0,1	
ELSE IF	Zone2	
ELSE IF	Zone3	
ELSE	zone 4,5	

The conditional settings for each rule are:

- IF Conditional:** Zone 0,1. Value1: CompositeStorage, Value2: 1, Operator: <=.
- ELSE IF Conditional:** Zone2. Value1: CompositeStorage, Value2: 2, Operator: =.
- ELSE IF Conditional:** Zone3. Value1: CompositeStorage, Value2: 3, Operator: =.
- ELSE Conditional:** zone 4,5.

The detailed views for Atlanta Min_FWS_Z1, Atlanta Min_FWS_Z2, Atlanta Min_FWS_Z3, and Atlanta Min_FWS_Z4 show the monthly flow (cfs) and a corresponding graph. The flow values are as follows:

Date	Flow (cfs)
01Jan	1910.0
01Feb	2270.0
01Mar	2470.0
01Apr	2400.0
01May	2130.0
01Jun	1610.0
01Jul	1330.0
01Aug	1220.0
01Sep	1010.0
01Oct	1020.0
01Nov	1200.0
01Dec	1410.0

Date	Flow (cfs)
01Jan	800.0
01Feb	1170.0
01Mar	1390.0
01Apr	1470.0
01May	800.0
01Jun	800.0
01Jul	800.0
01Aug	800.0
01Sep	800.0
01Oct	800.0
01Nov	800.0
01Dec	800.0

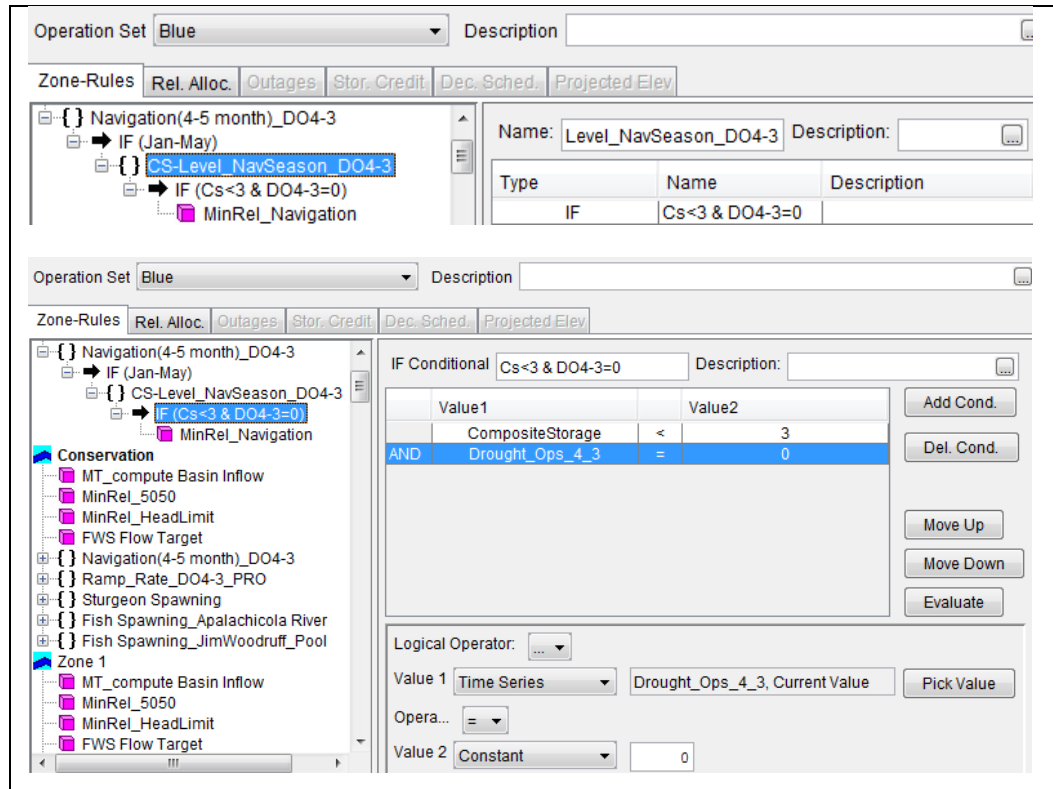


Figure K.84 Release Rules for Navigation (4-5)month_DO4-3

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.

Appendix K – Development of Alternatives

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.

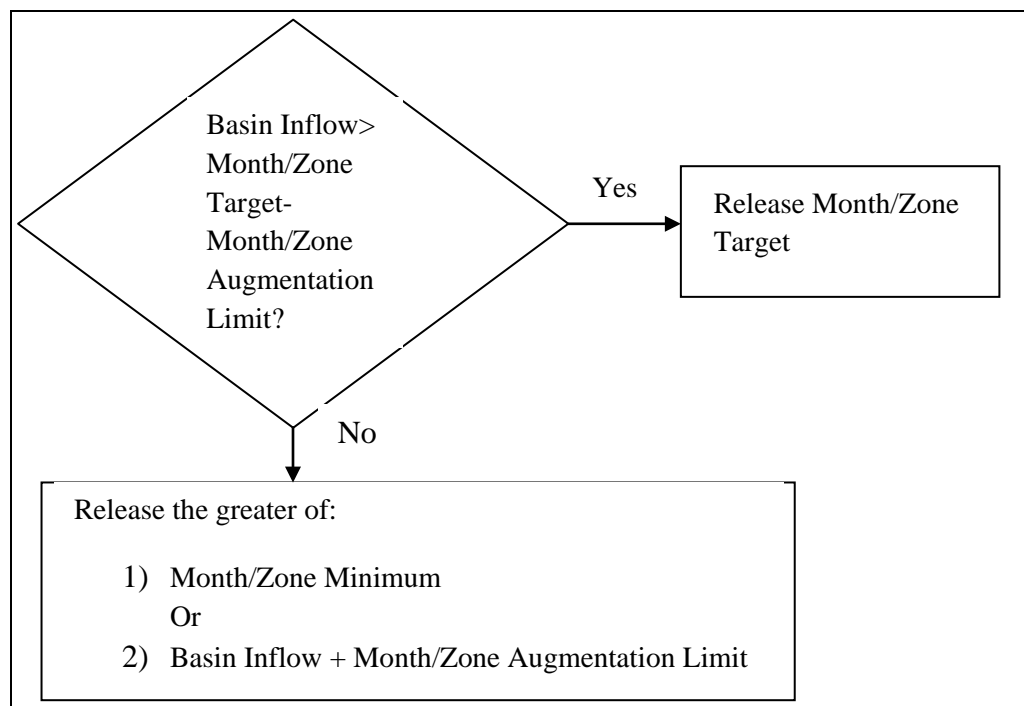


Figure K.85 FWS Flow Target

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.

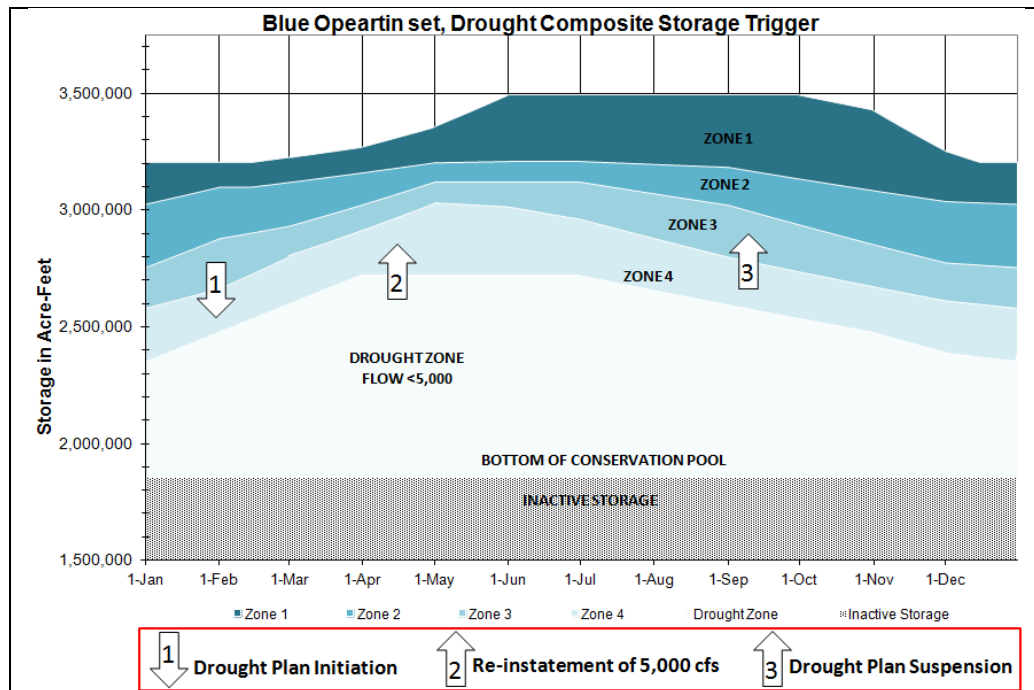


Figure K.86 Alternative 6-Drought Composite Storage Triggers

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
<i>Buford</i>	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
<i>Jim Woodruff</i>	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)

Operation Set: Gold Description: This Ops is set for.

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Eley

Name: power Gen fn of drought_F Description:

Type	Name	Description
IF	DO3-1 EQ 1	
ELSE	RIOP	

(within **Conservation** zone)

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(within Zone2)

(within Zone3)

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.

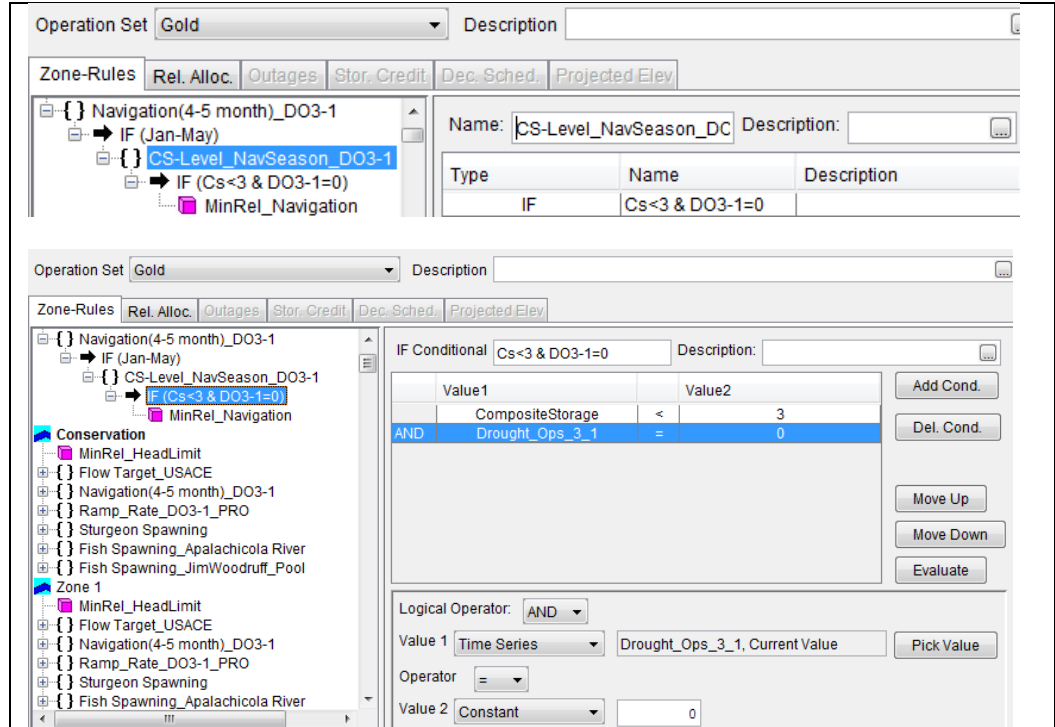


Figure K.88 Release Rules for Navigation (4-)month)_DO3-1Rule

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.

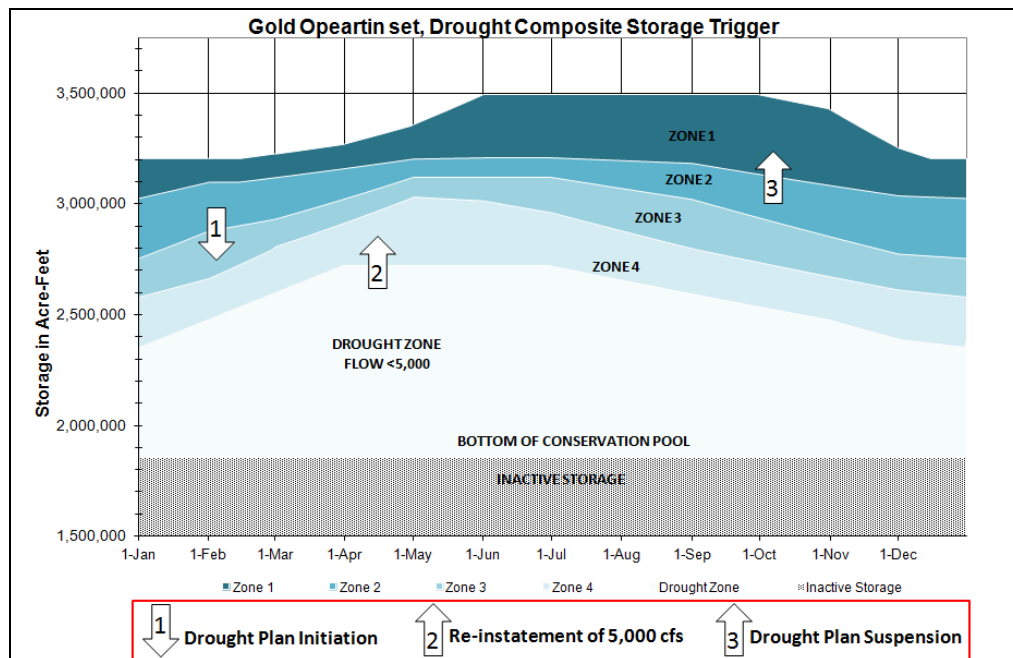


Figure K.89 Alternative 7-Drought Composite Storage Triggers

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

Appendix K – Development of Alternatives

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

Appendix K – Development of Alternatives

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.

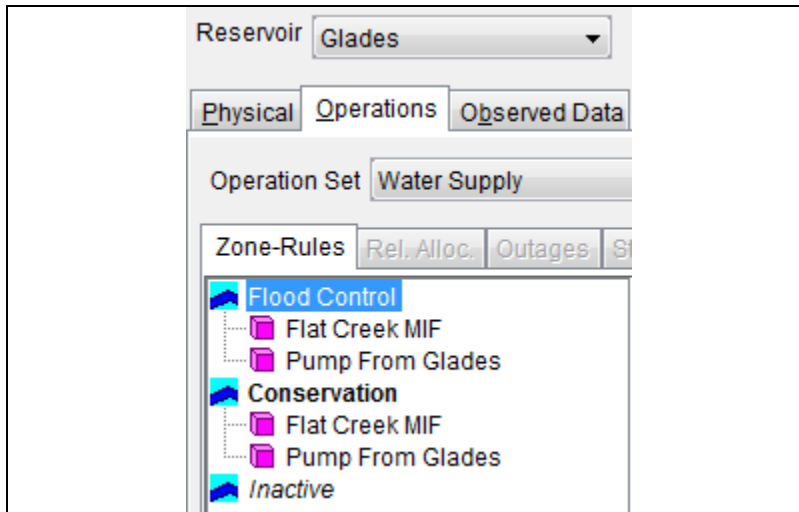


Figure K.91 Rule Set for Glades Water Supply Operation Set

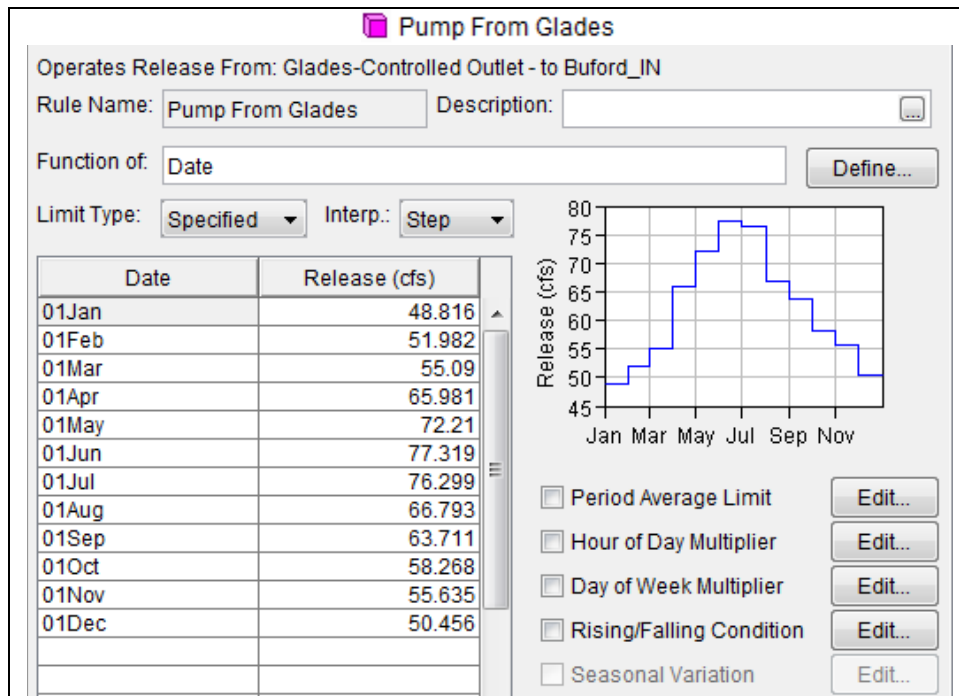


Figure K.92 Glades Reservoir –Pump From Glades rule

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.

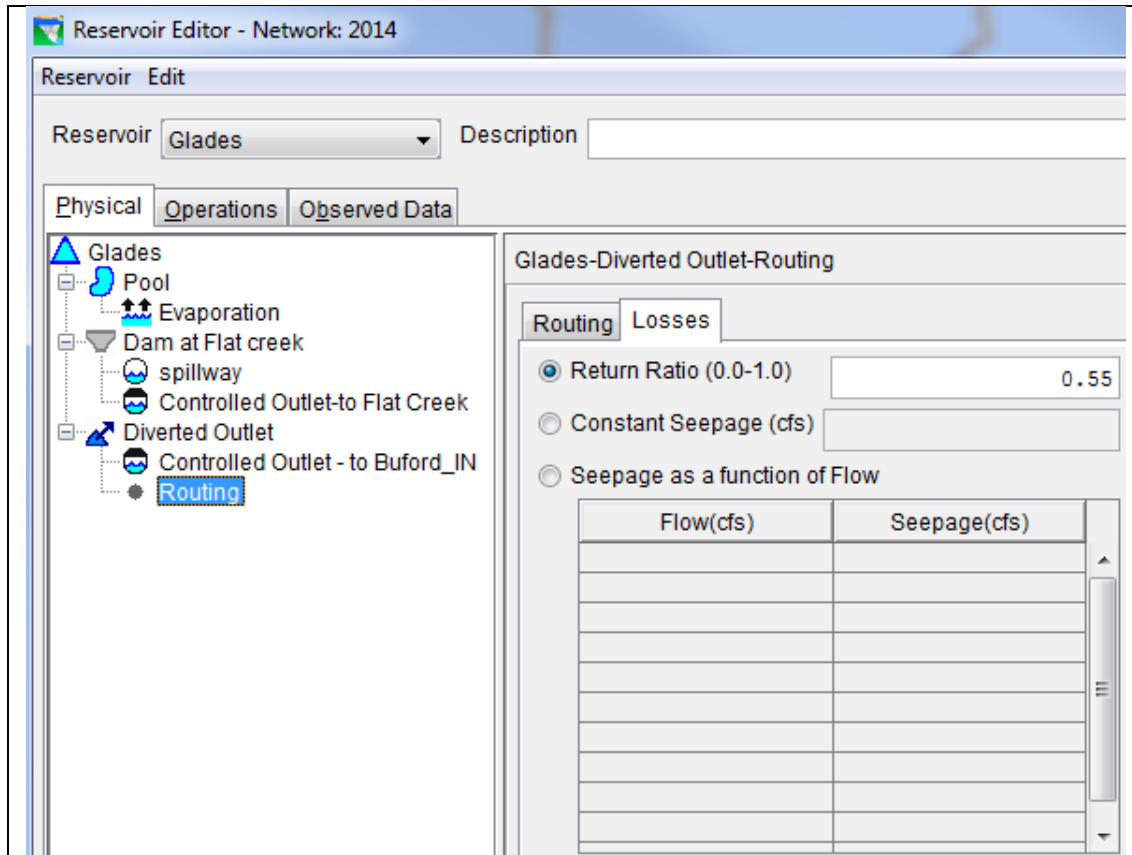


Figure K.93 Return rate from Glades to Buford-Water supply options C and E

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.

1

Appendix F

2

ACF Basin Critical Yield Report

3

1
2

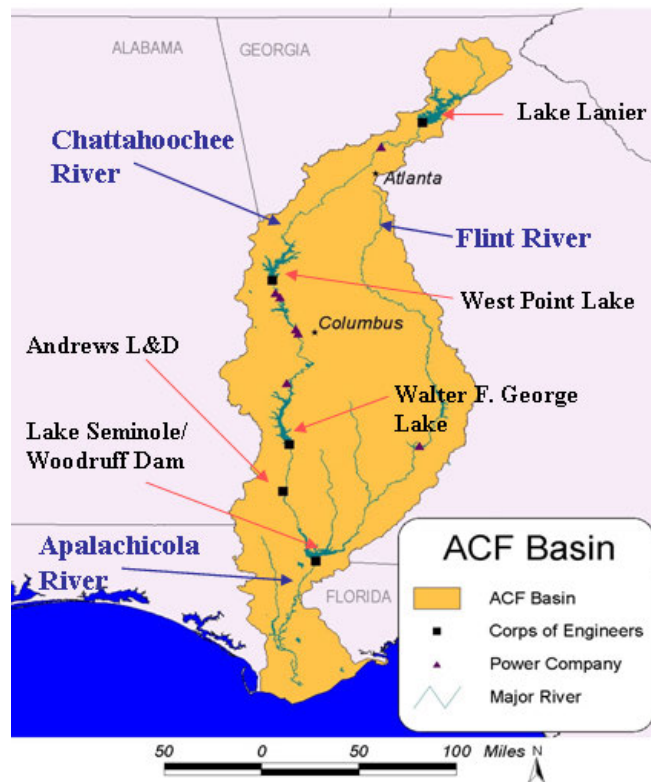
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**US Army Corps
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Mobile District

FEDERAL STORAGE RESERVOIR CRITICAL YIELD ANALYSES

APALACHICOLA-CHATTAHOOCHEE-FLINT (ACF) RIVER BASIN



April 2015

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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:

$$1 \text{ cfs} = 0.6464 \text{ mgd} = 722.7 \text{ ac-ft/yr}$$

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 is 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.

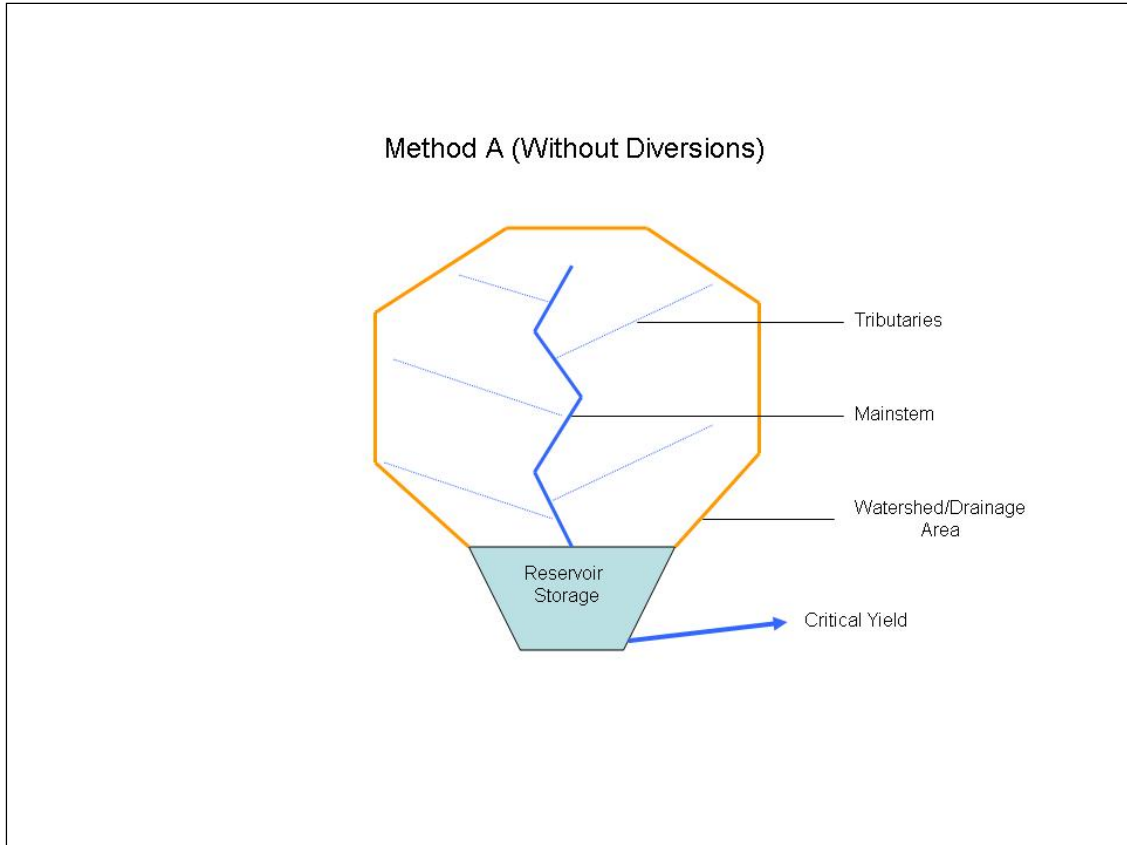


Figure 2. Critical Yield Method A (Without Diversions)

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.

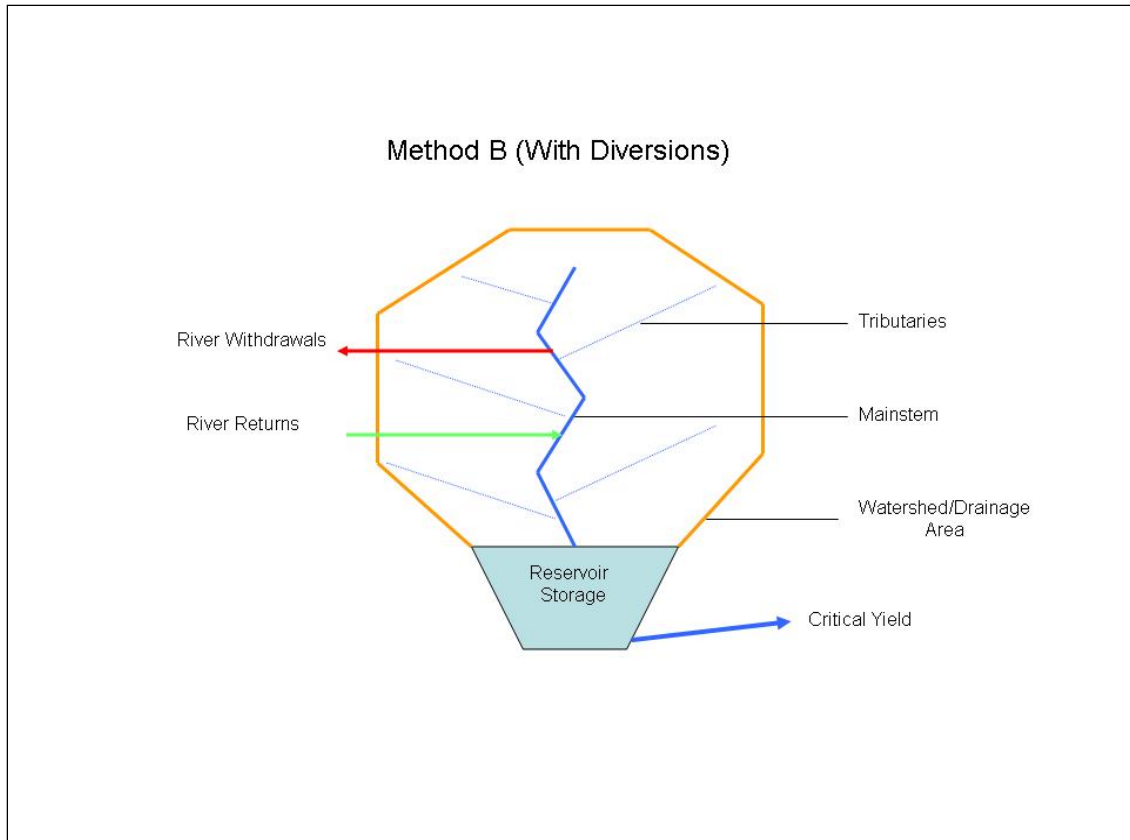


Figure 3. Critical Yield Method B (With Diversions)

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.

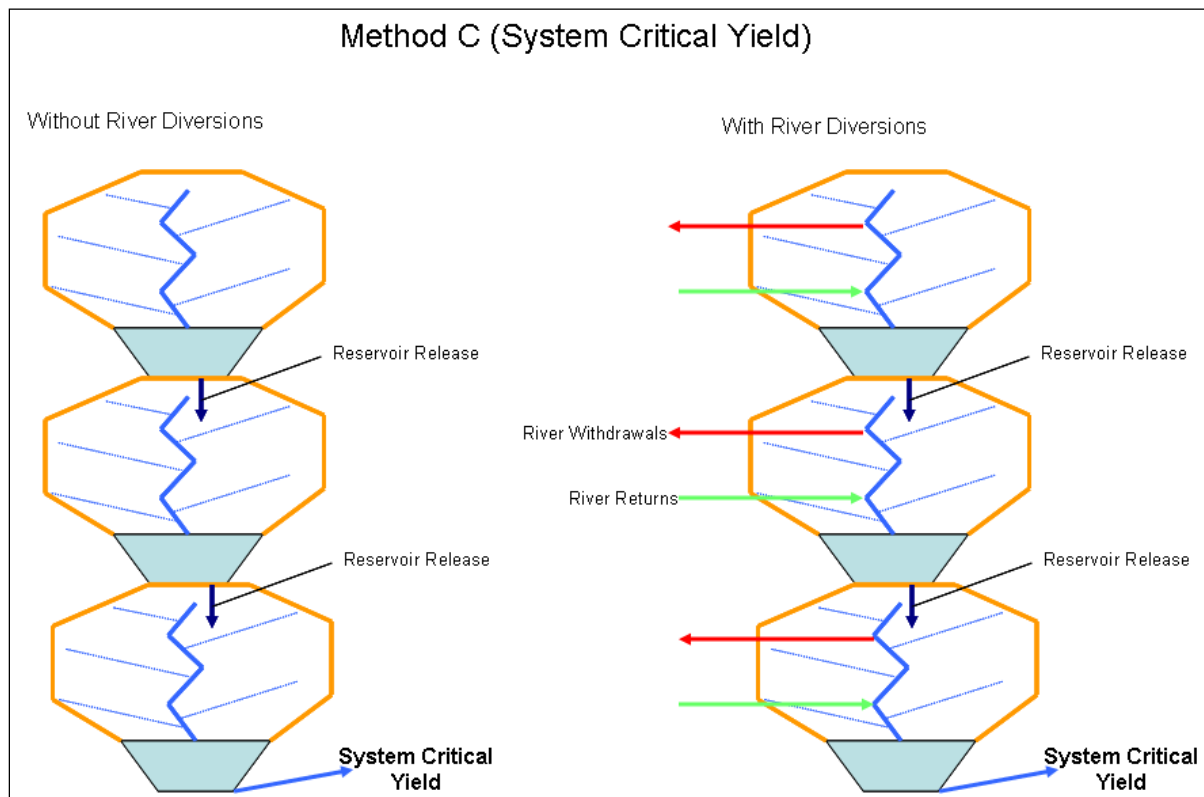


Figure 4. Critical Yield Method C (River System Yield)

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.

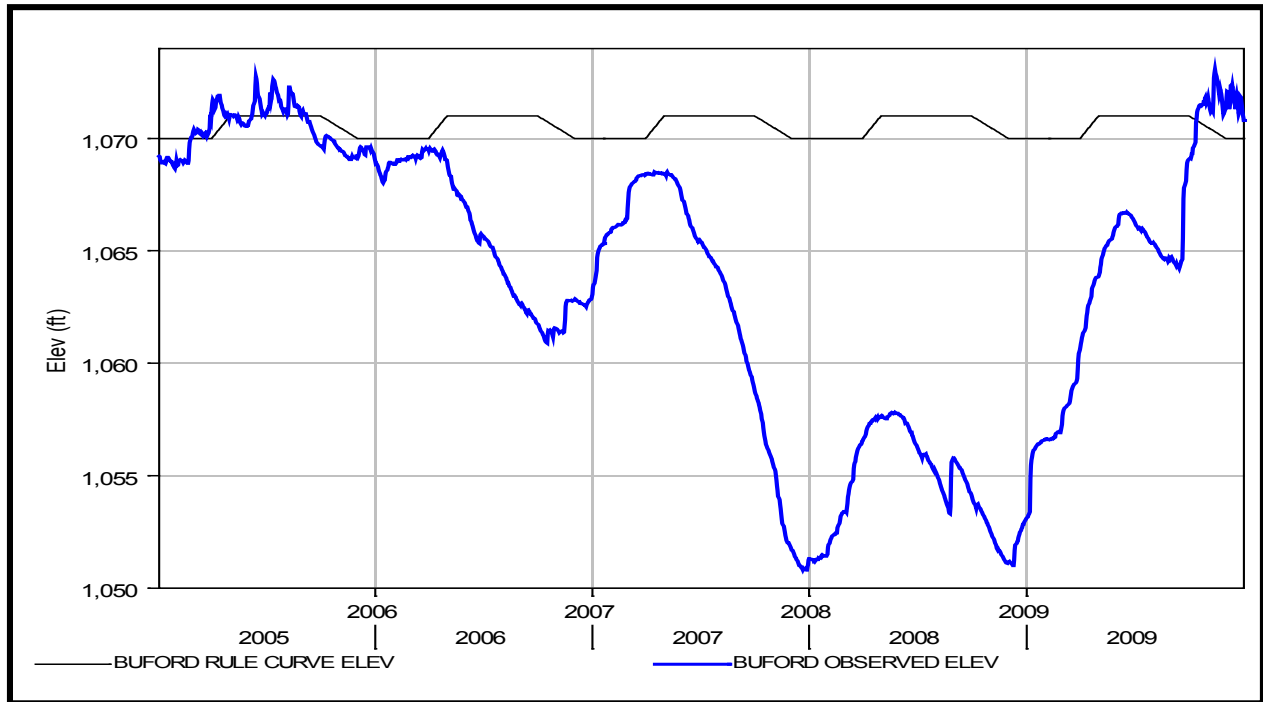


Figure A-1. Lake Lanier Pool Elevation 2005-2009

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.

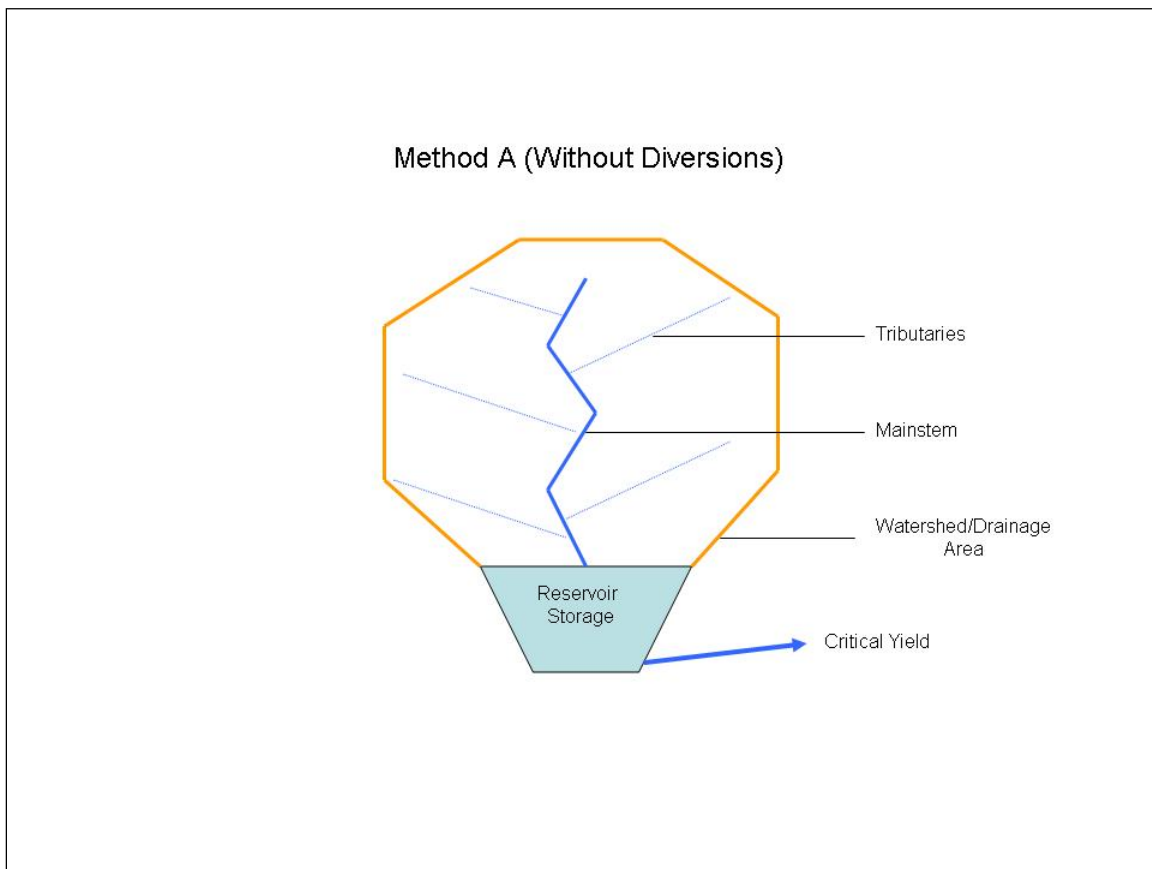


Figure A-2. Critical Yield Method A (Without Diversions)

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.

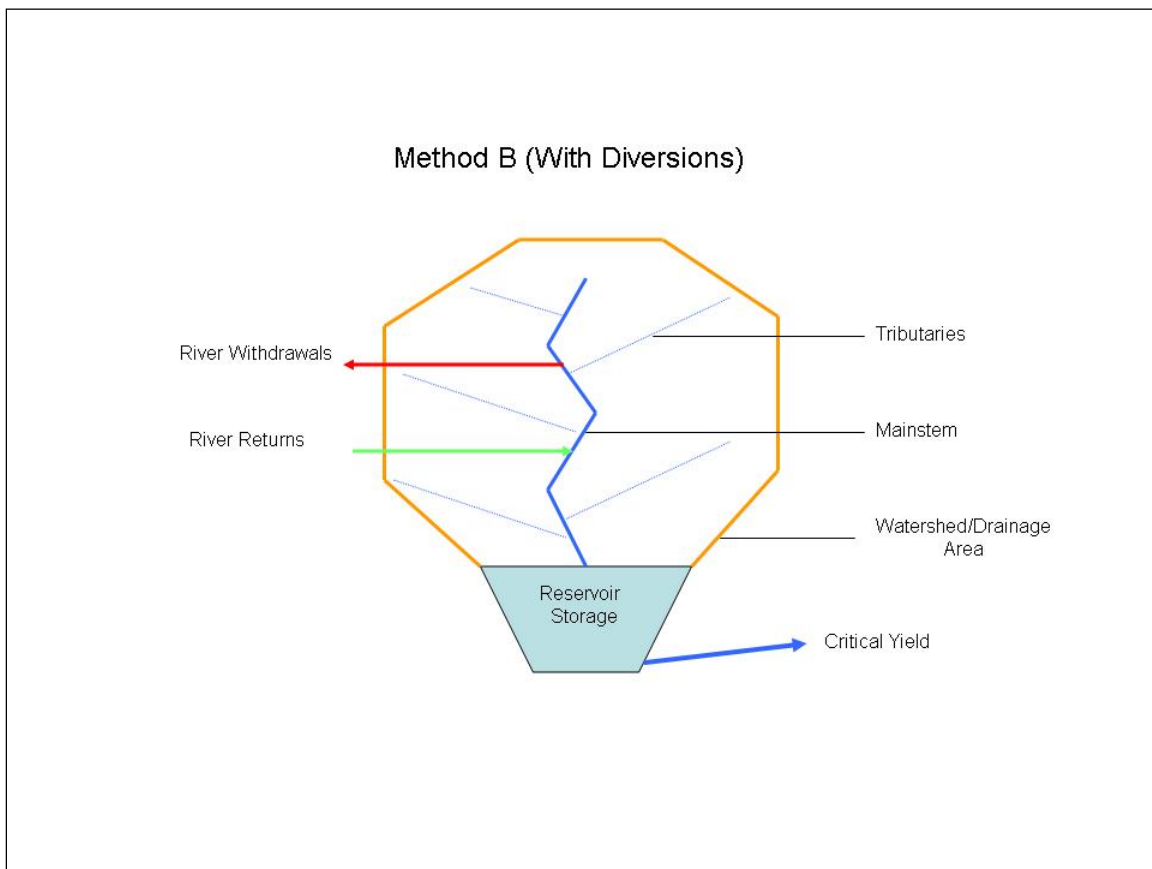


Figure A-3. Critical Yield Method B (With Diversions)

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.

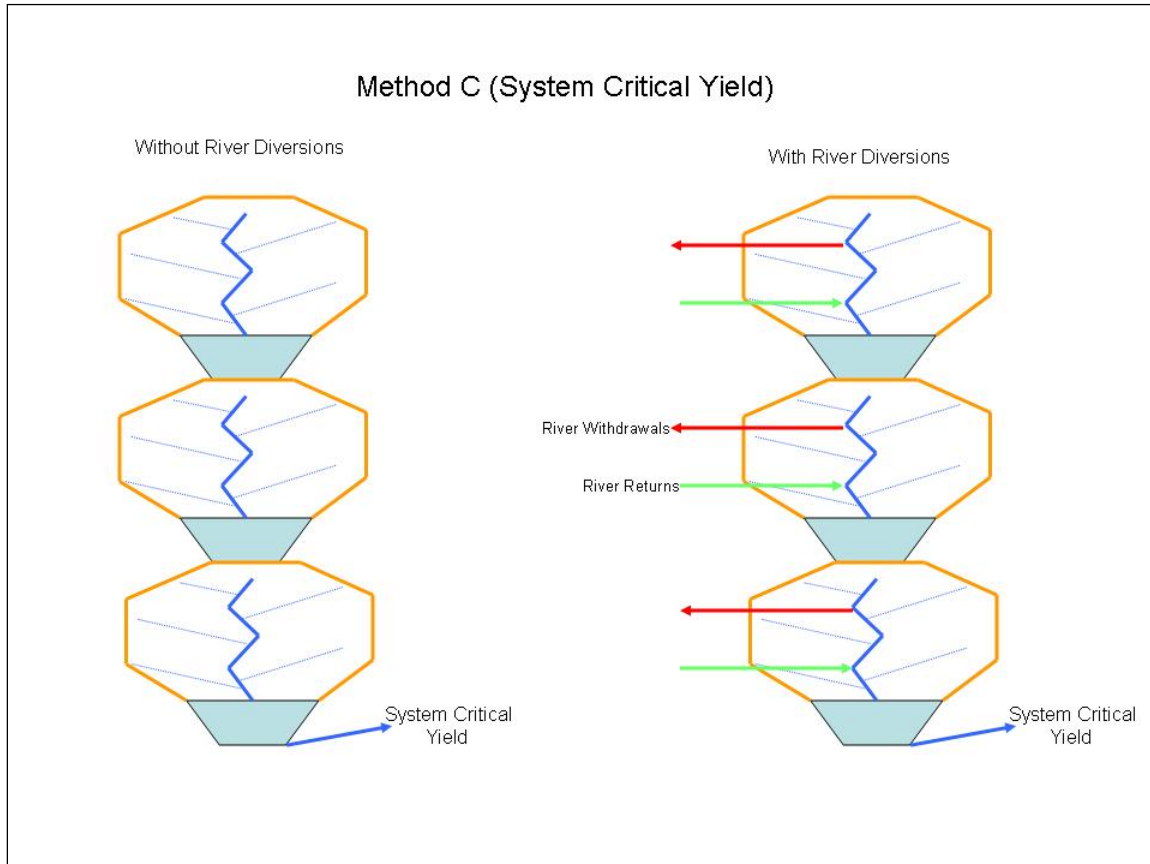


Figure A-4. Critical Yield Method C (System Critical Yield)

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.

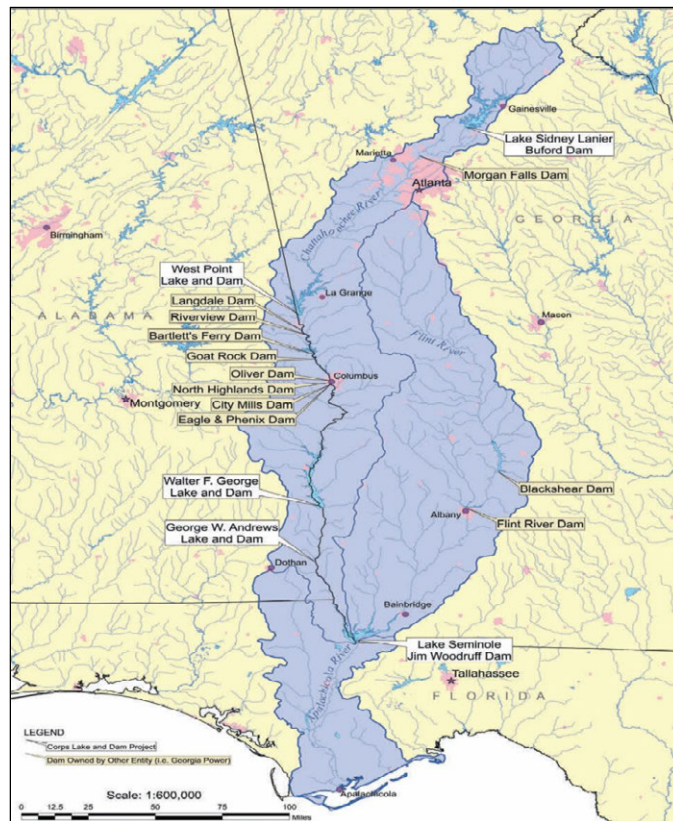


Figure B-1. ACF Basin

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

B-5

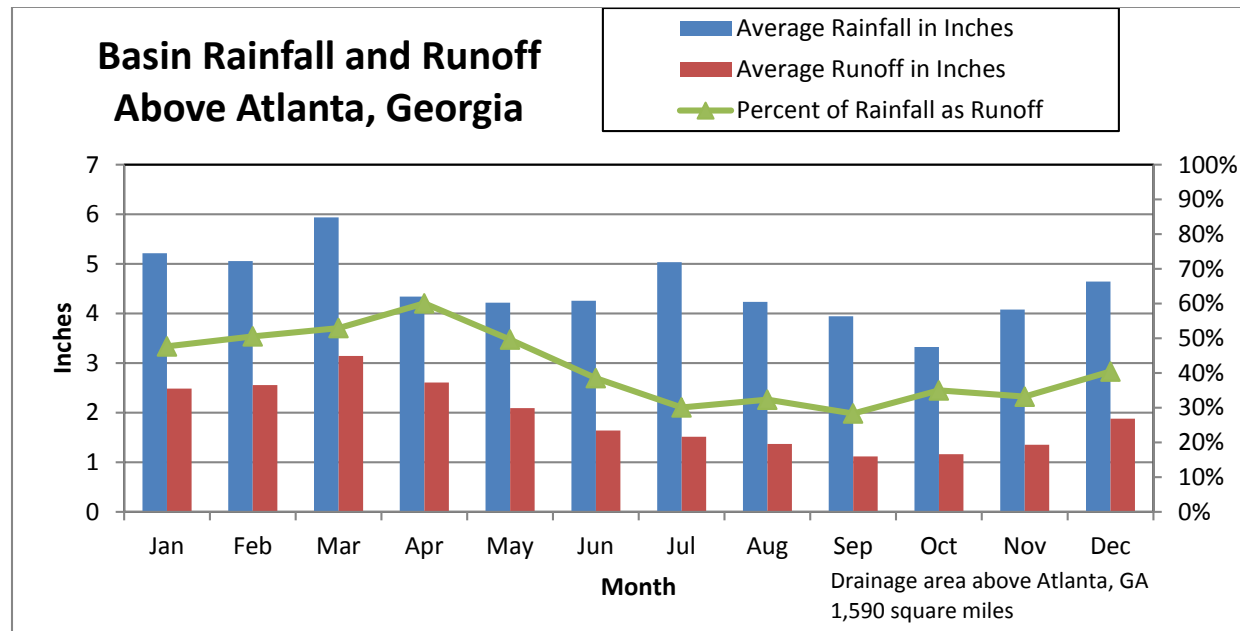


Figure B-2. Basin Rainfall and Runoff above Atlanta, Georgia (1939-2011)

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

B-6

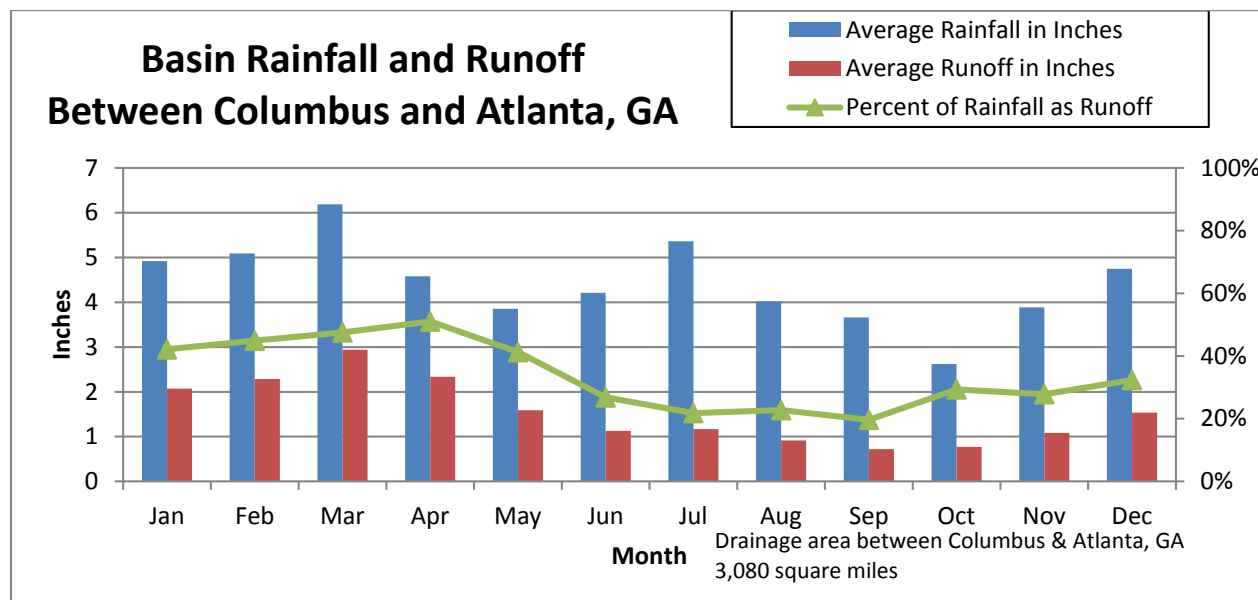


Figure B-3. Basin Rainfall and Runoff between Columbus and Atlanta, Georgia (1939-2011)

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

B-7

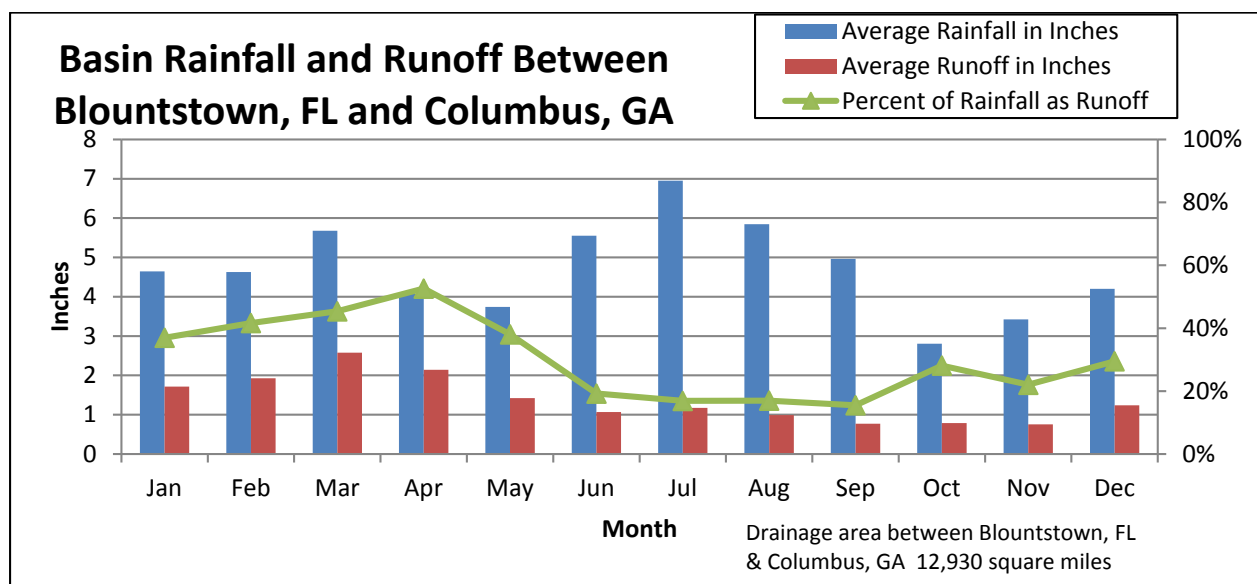


Figure B-4. Basin Rainfall and Runoff between Blountstown, FL and Columbus, GA (1939-2011)

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	

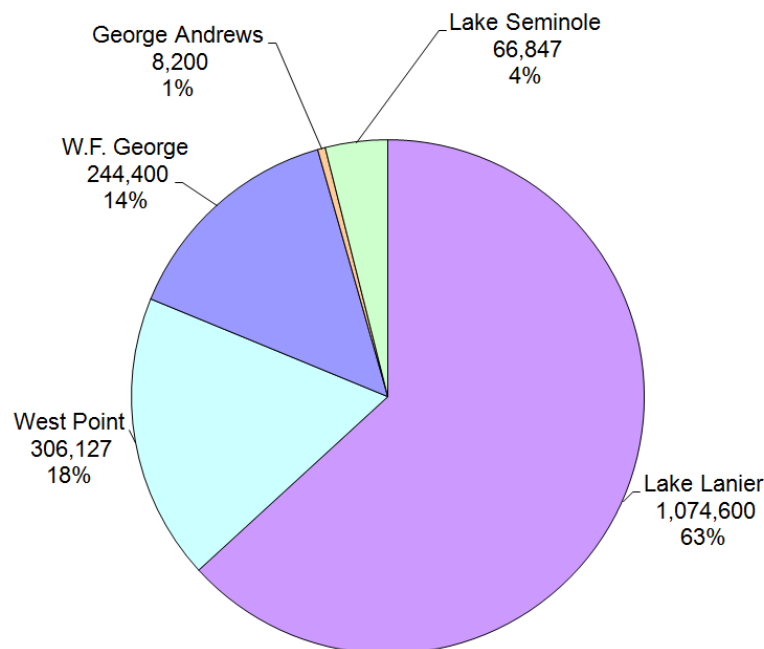


Figure B-5. ACF Basin Federal Reservoir Conservation Storage Percent by Acre-Feet

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.

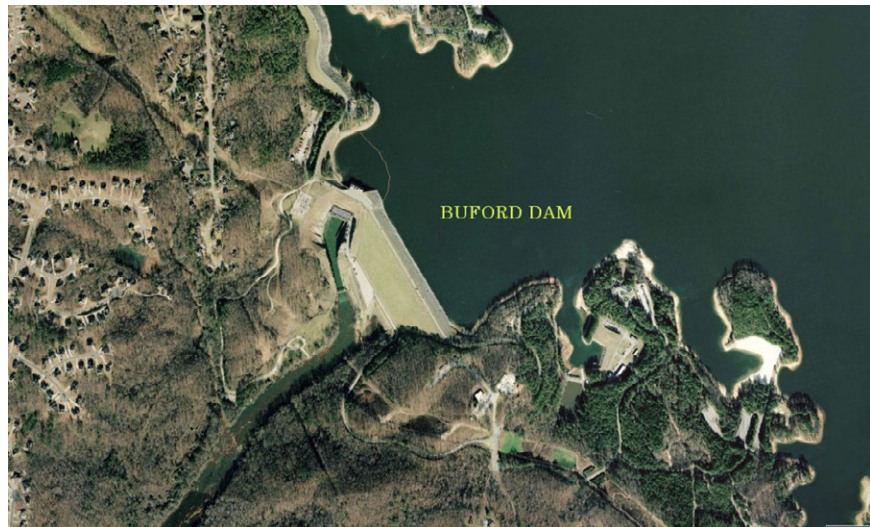


Figure B-6. Buford Dam

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.

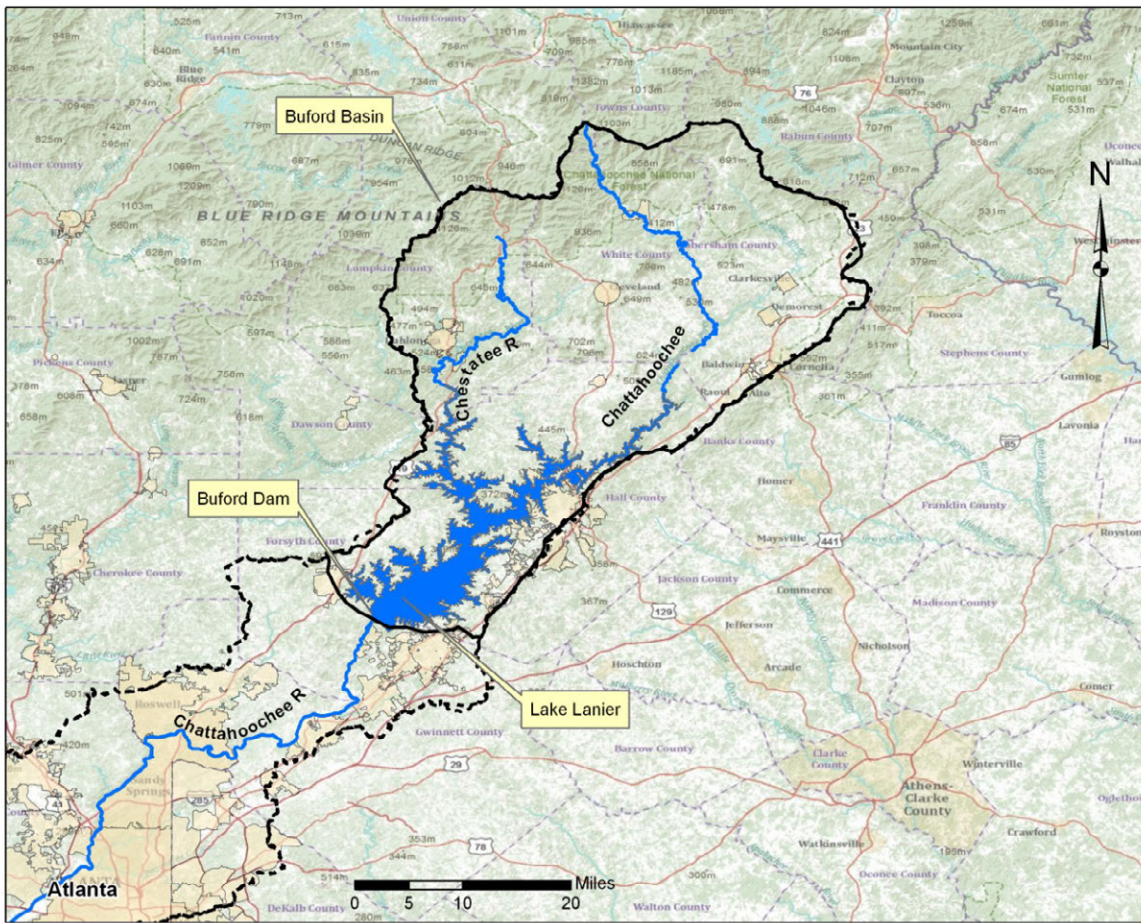


Figure B-7. Buford Basin Map

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.

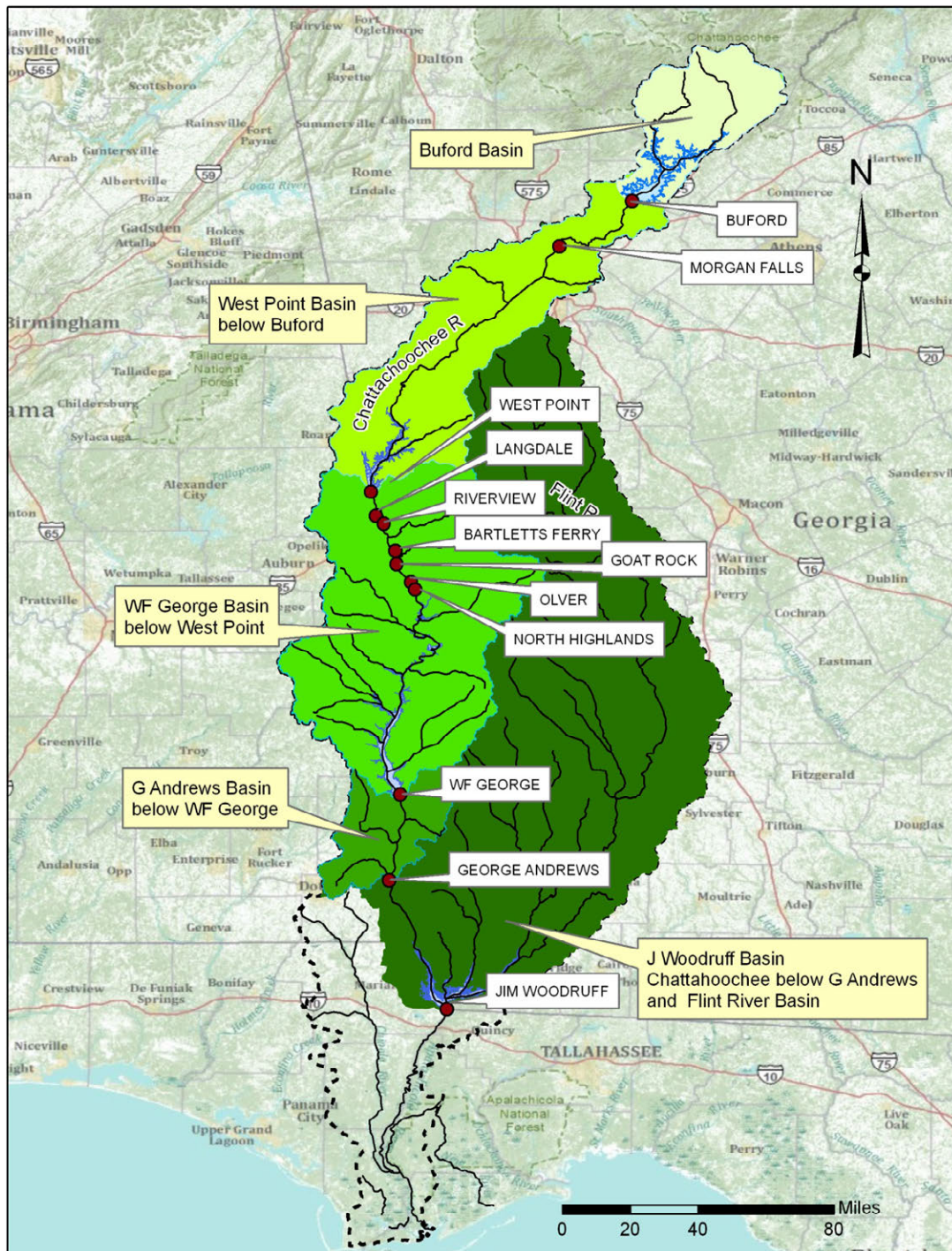


Figure B-8. Incremental Drainage Basin Map for Federal Projects on the ACF

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.

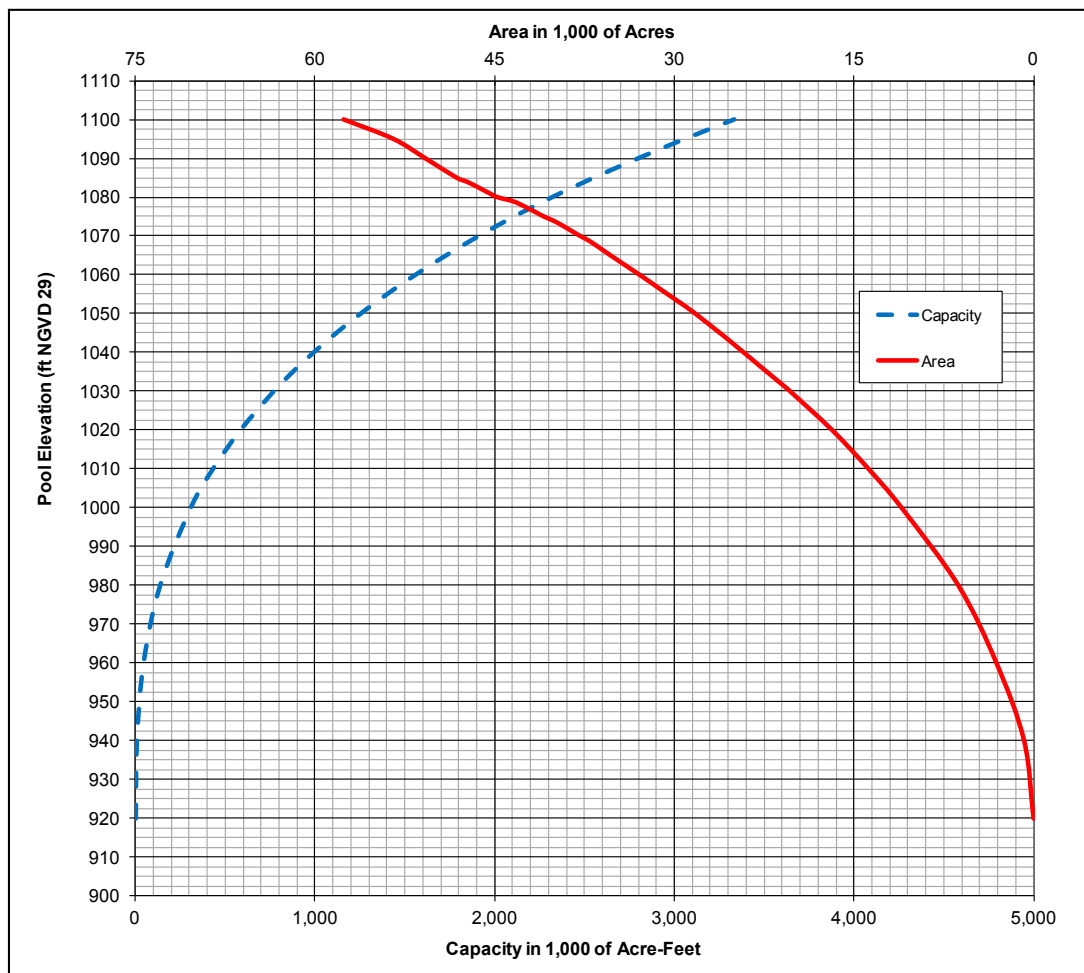


Figure B-9. Buford Area – Capacity Curves (circa 2011)

Table B-5. Buford Reservoir Area and Capacity Data (circa 2011)

Pool	Total	Total
Elev	Area	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

Pool	Total	Total
Elev	Area	Storage
(ft NGVD 29)	(ac)	(ac-ft)
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 until 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.

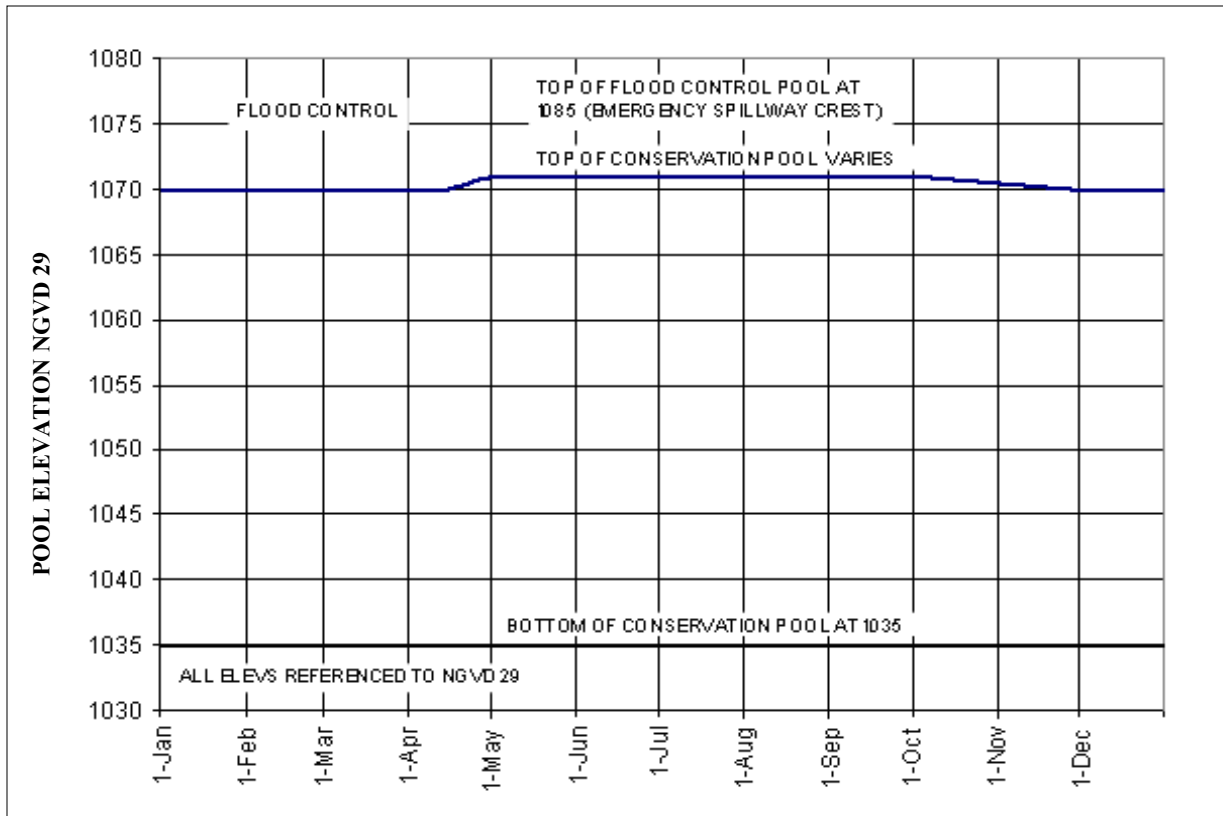


Figure B-10. Top and Bottom of Buford Conservation Pool

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.

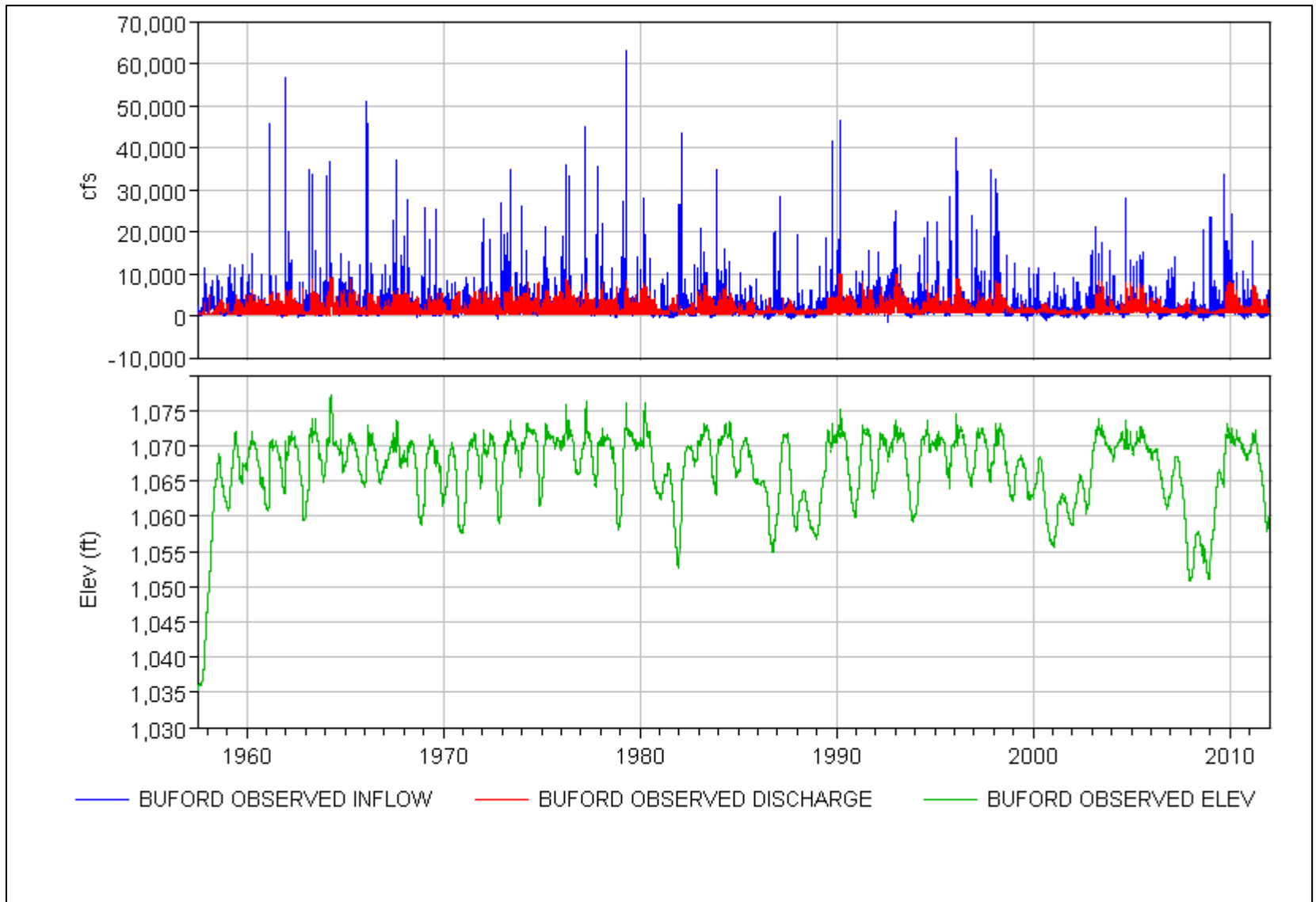


Figure B-11. Buford Inflow-Outflow-Pool Elevation (Jul 1957-Dec 2011)

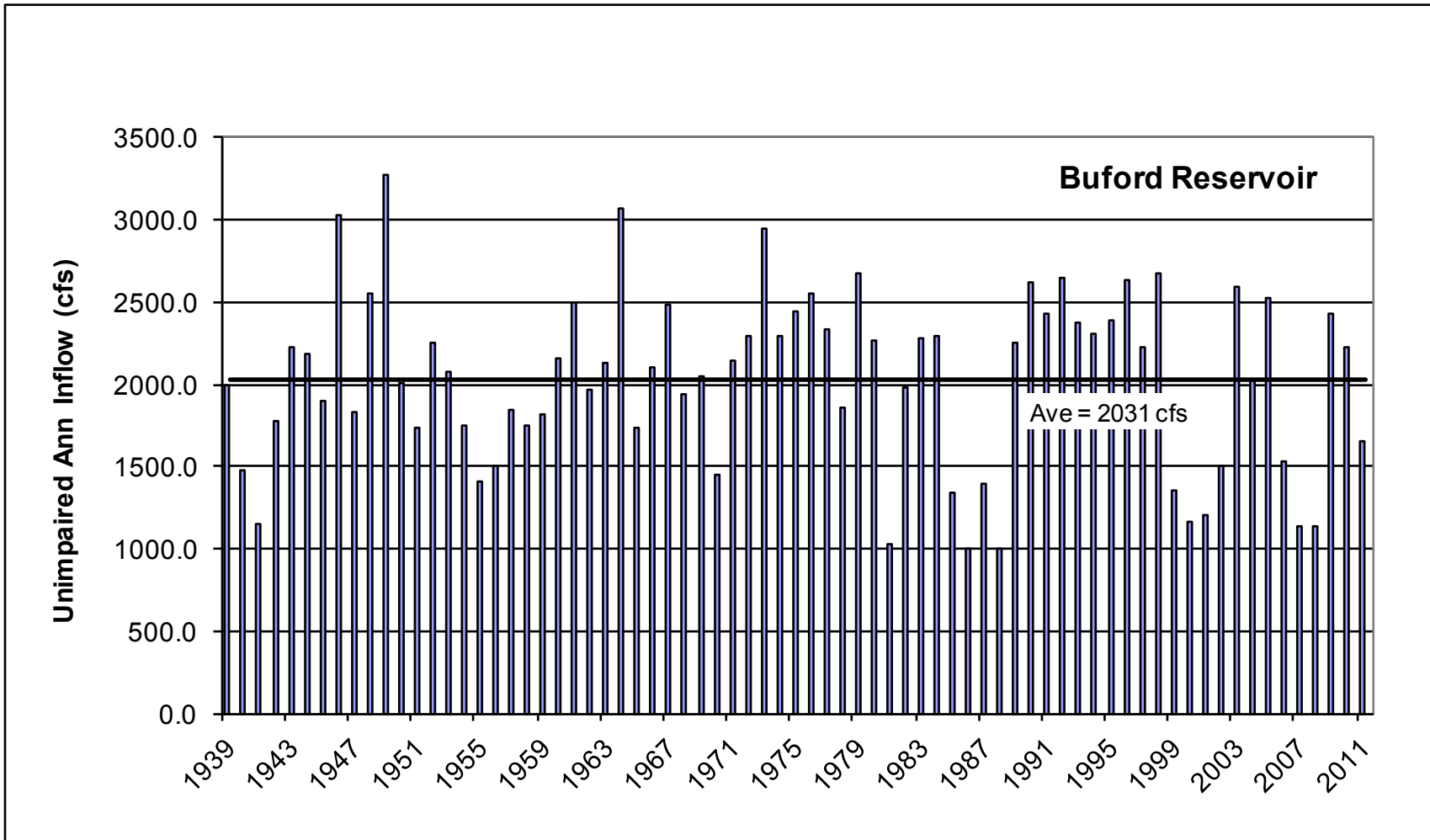


Figure B-12. Buford Unimpaired Annual Inflow Jan 1939 to Dec 2011

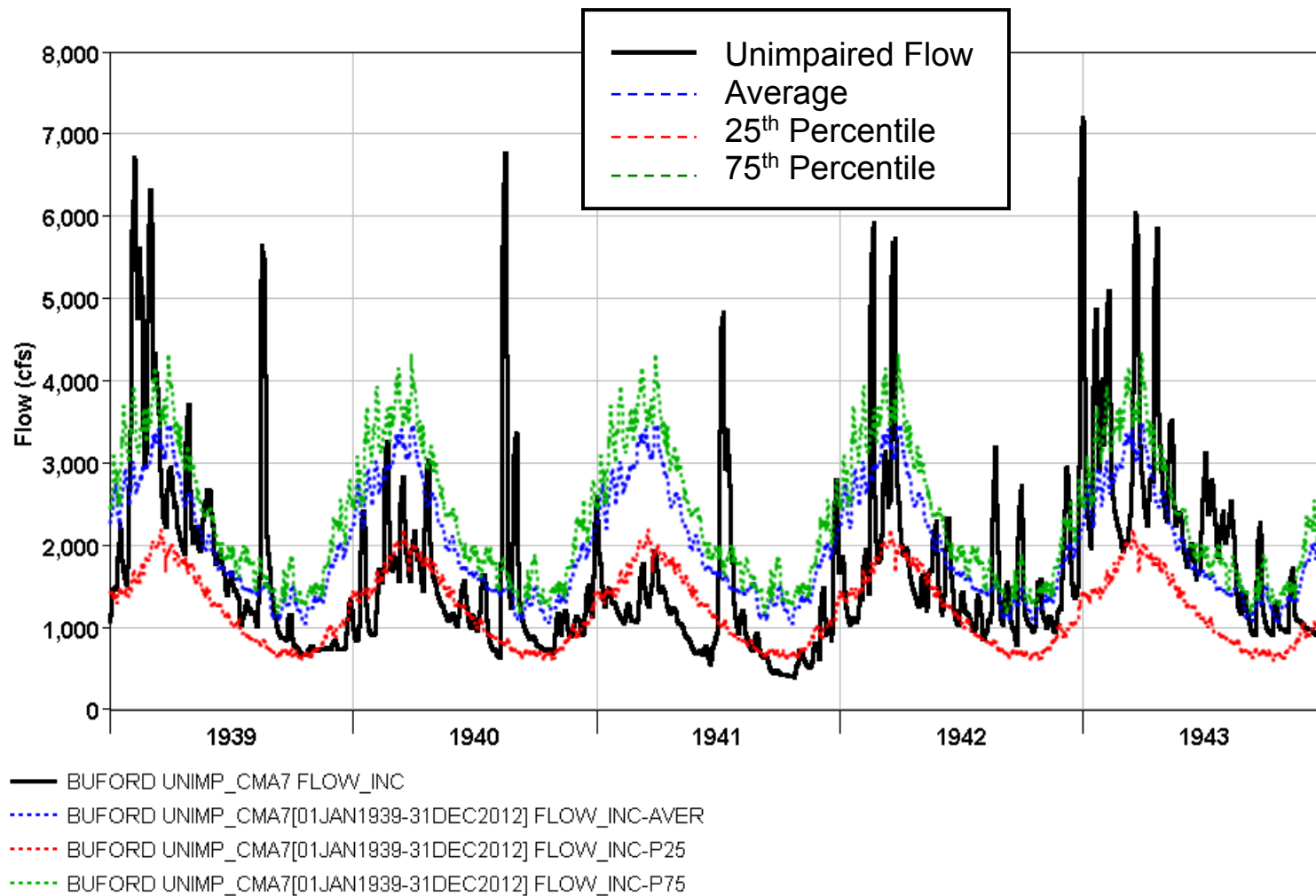


Figure B-13. Buford Unimpaired Inflow – 1940’s Drought

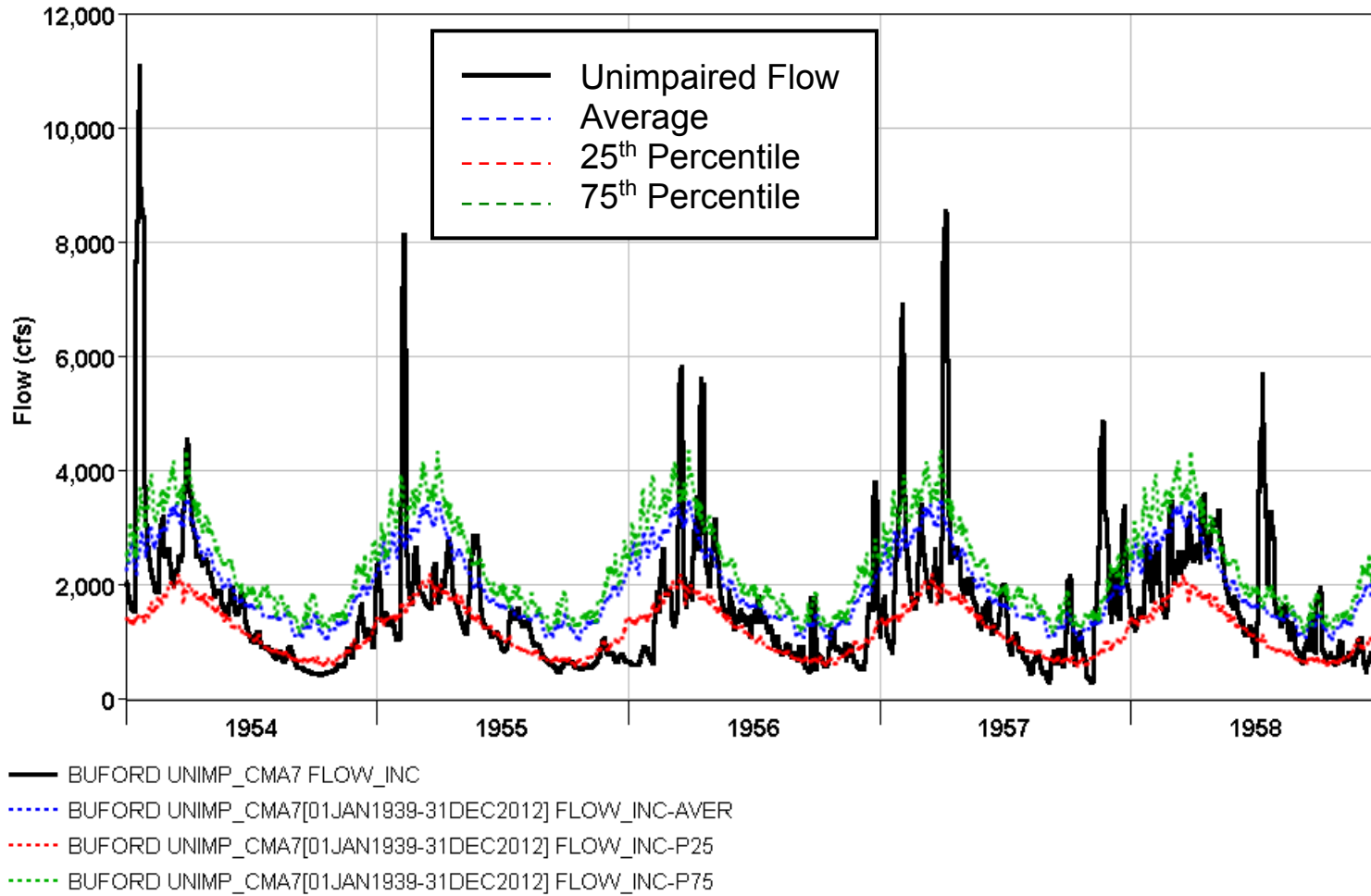


Figure B-14. Buford Unimpaired Inflow – 1950's Drought

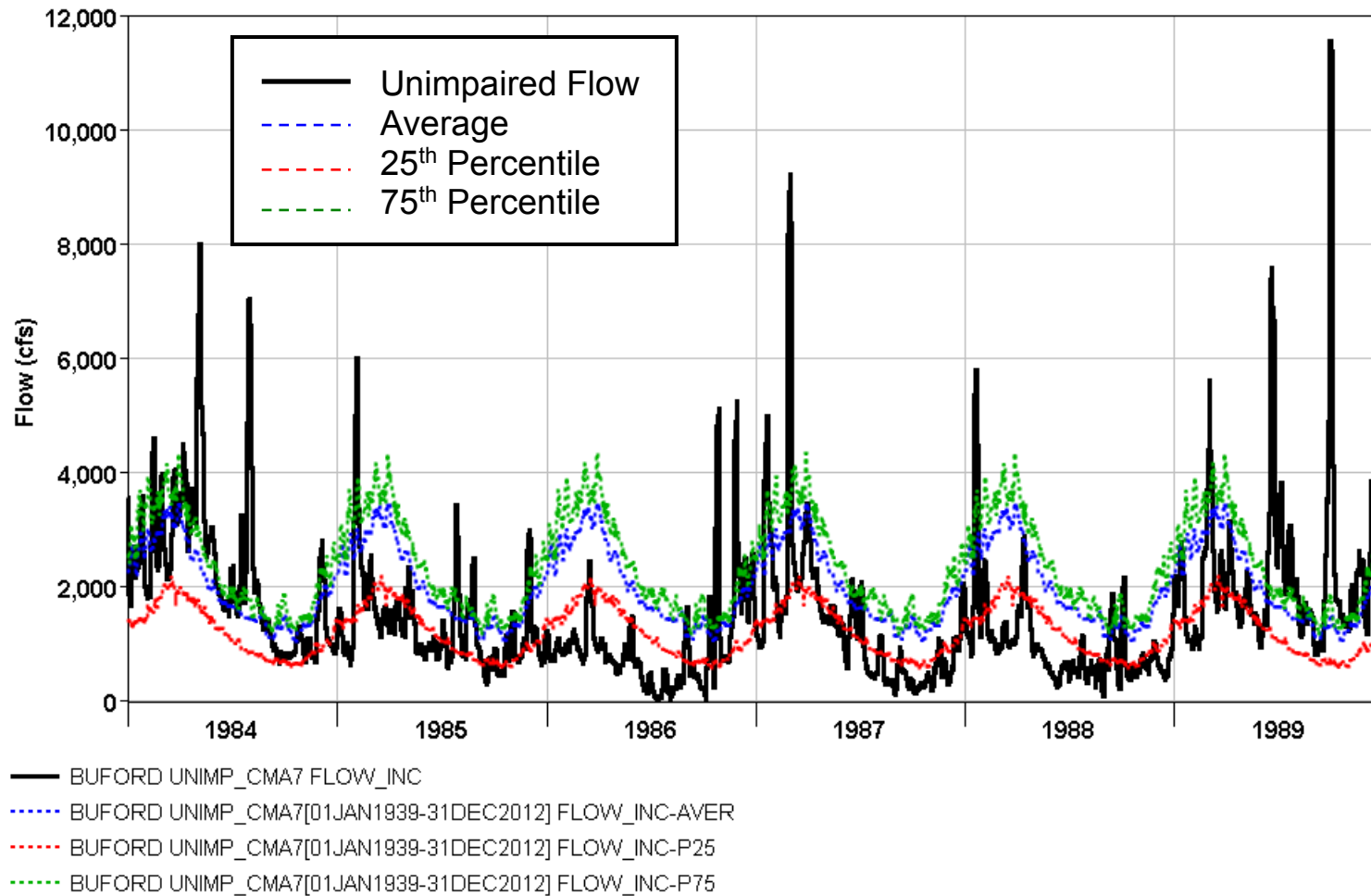


Figure B-15. Buford Unimpaired Inflow – 1980's Drought

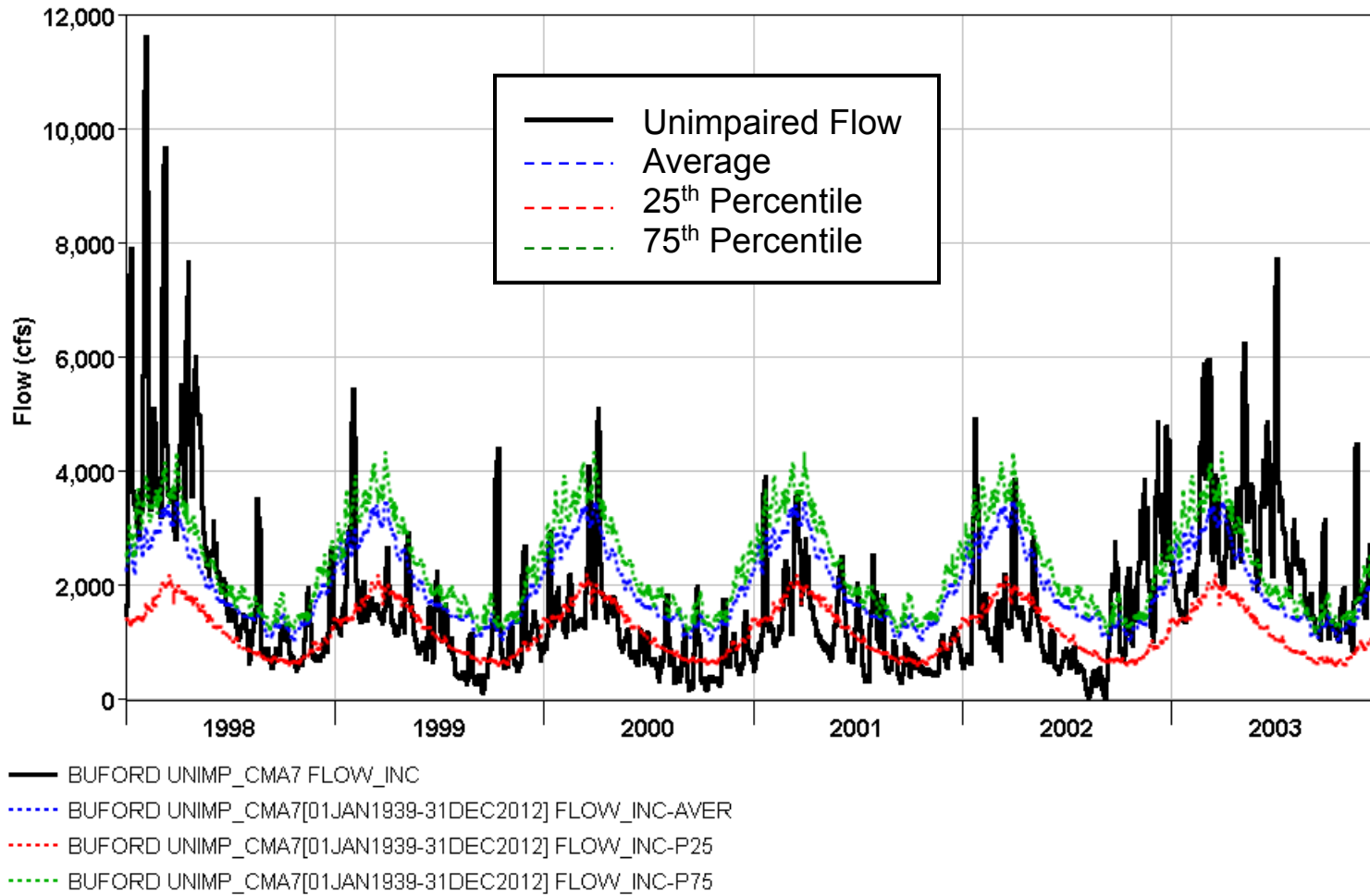


Figure B-16. Buford Unimpaired Inflow – 2000 Drought

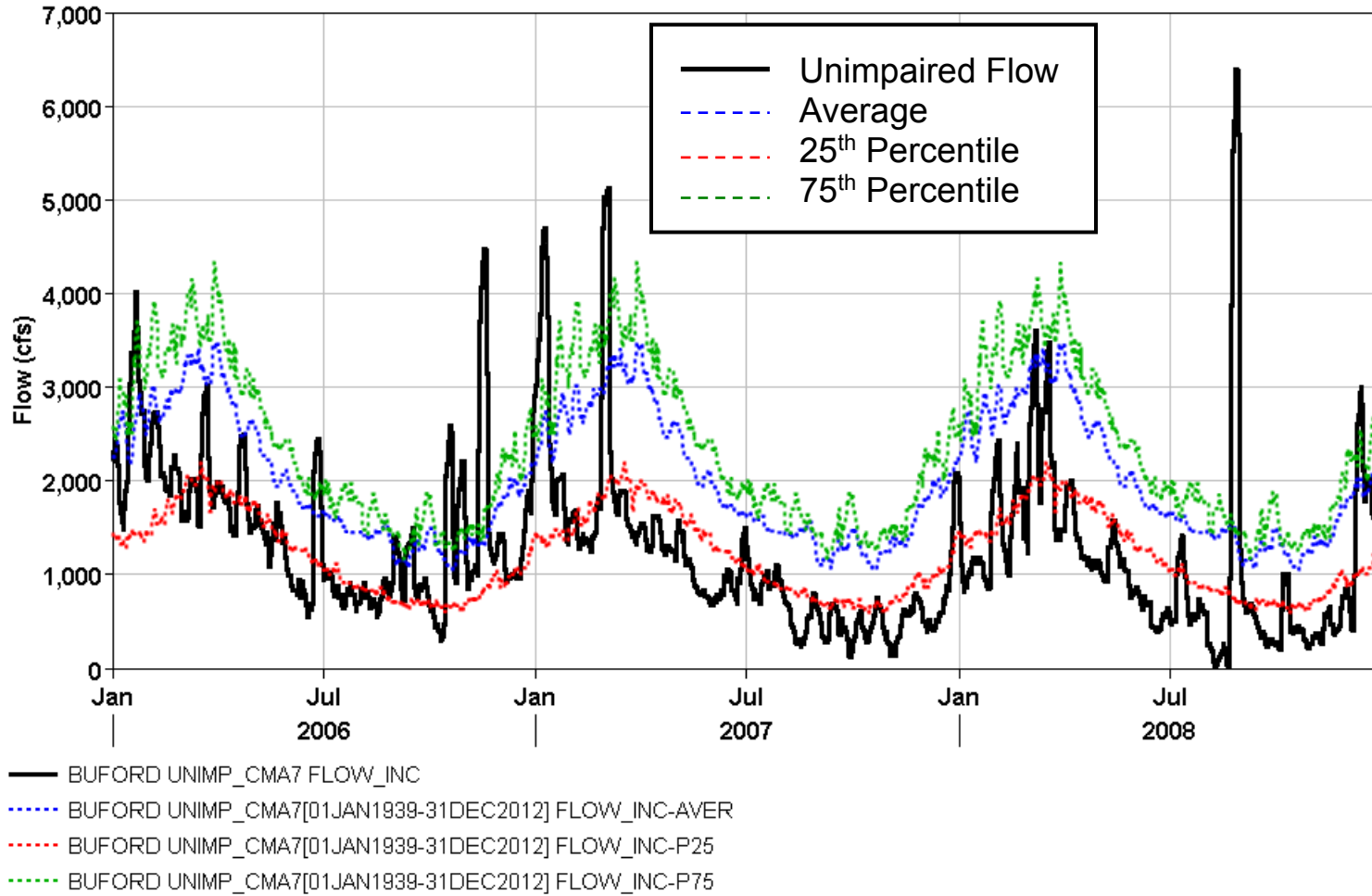


Figure B-17. Buford Unimpaired Inflow – 2007 Drought

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.

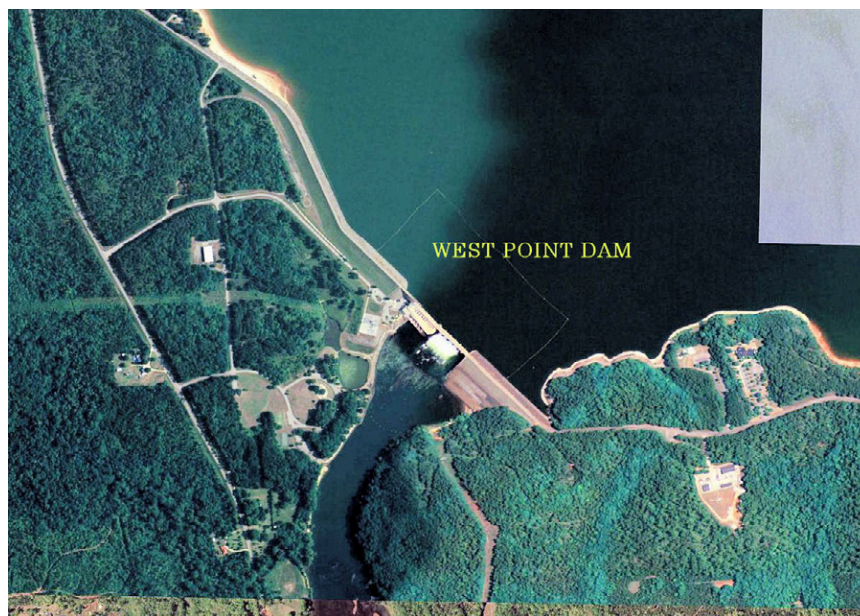


Figure B-18. West Point Dam

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.

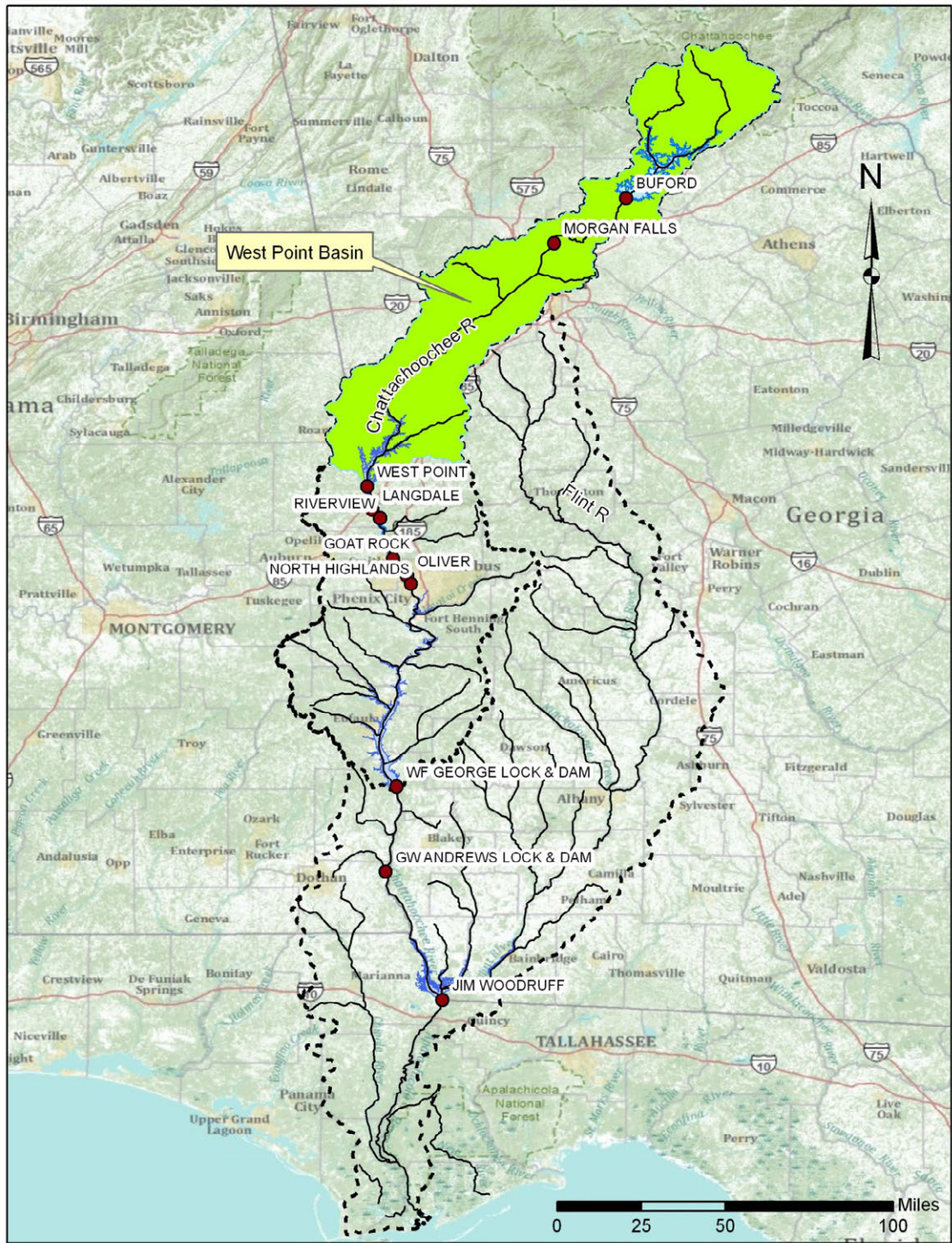


Figure B-19. West Point Basin Map

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.

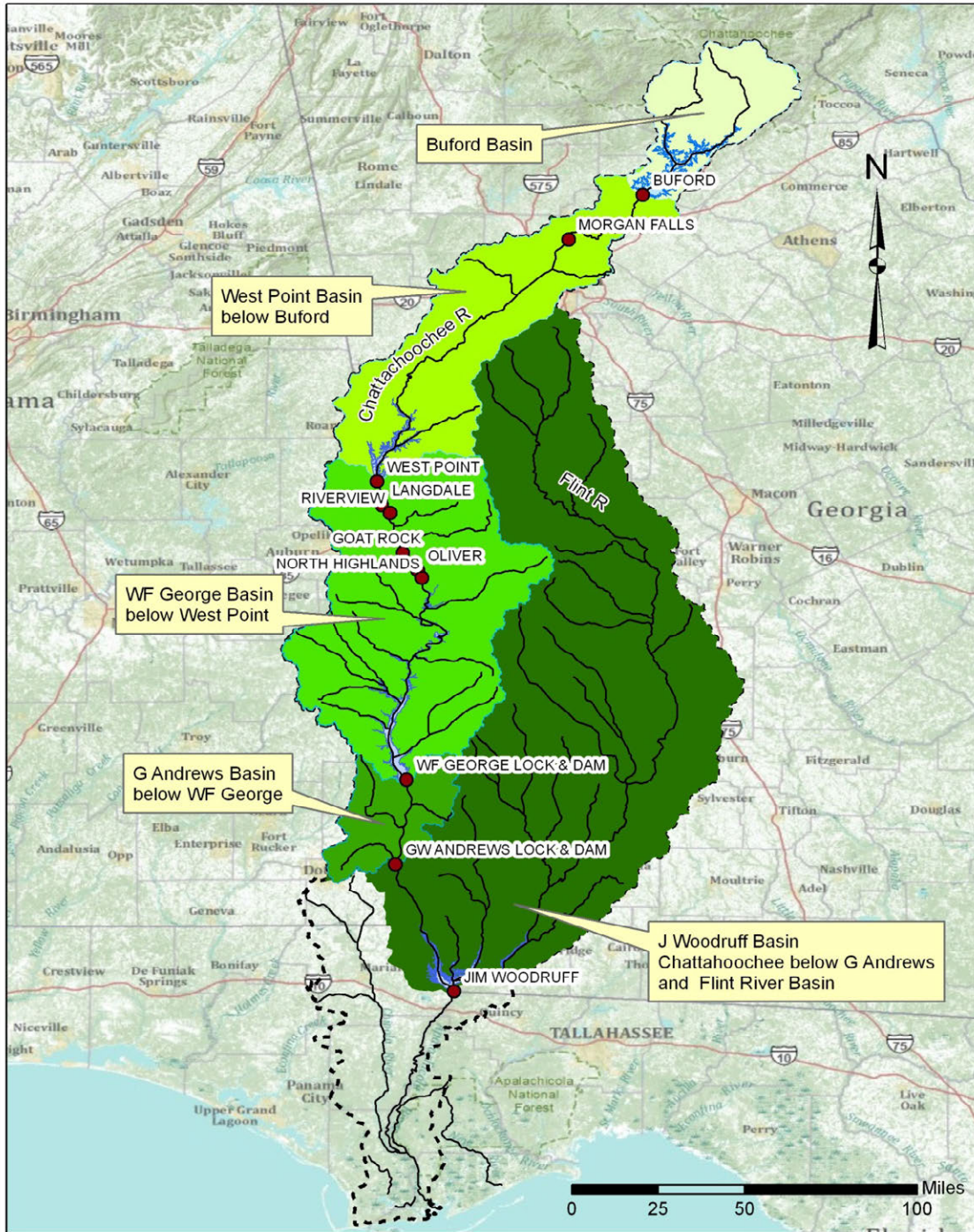


Figure B-20. Incremental Drainage Basin Map for Federal Projects on the ACF

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

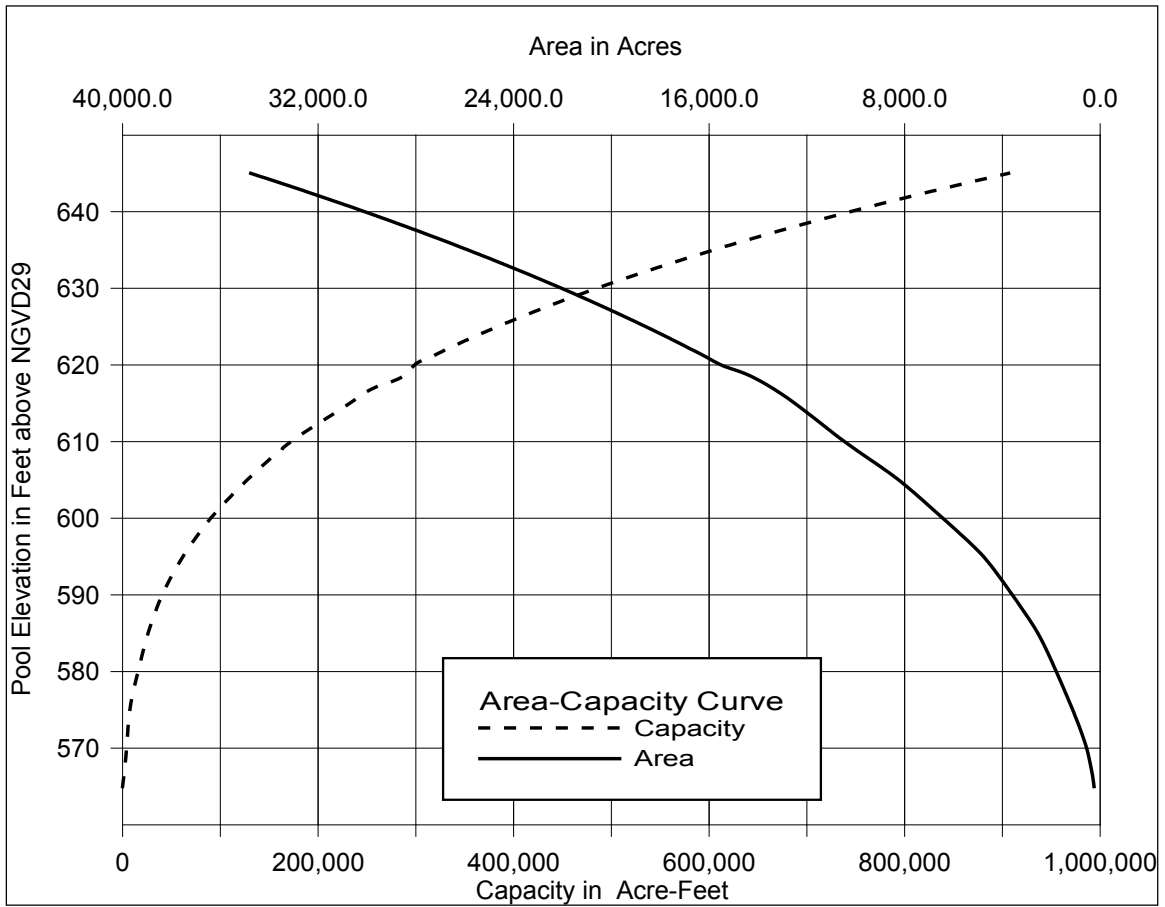


Figure B-21. West Point Area – Capacity Curves (circa 1975)

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 until 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.

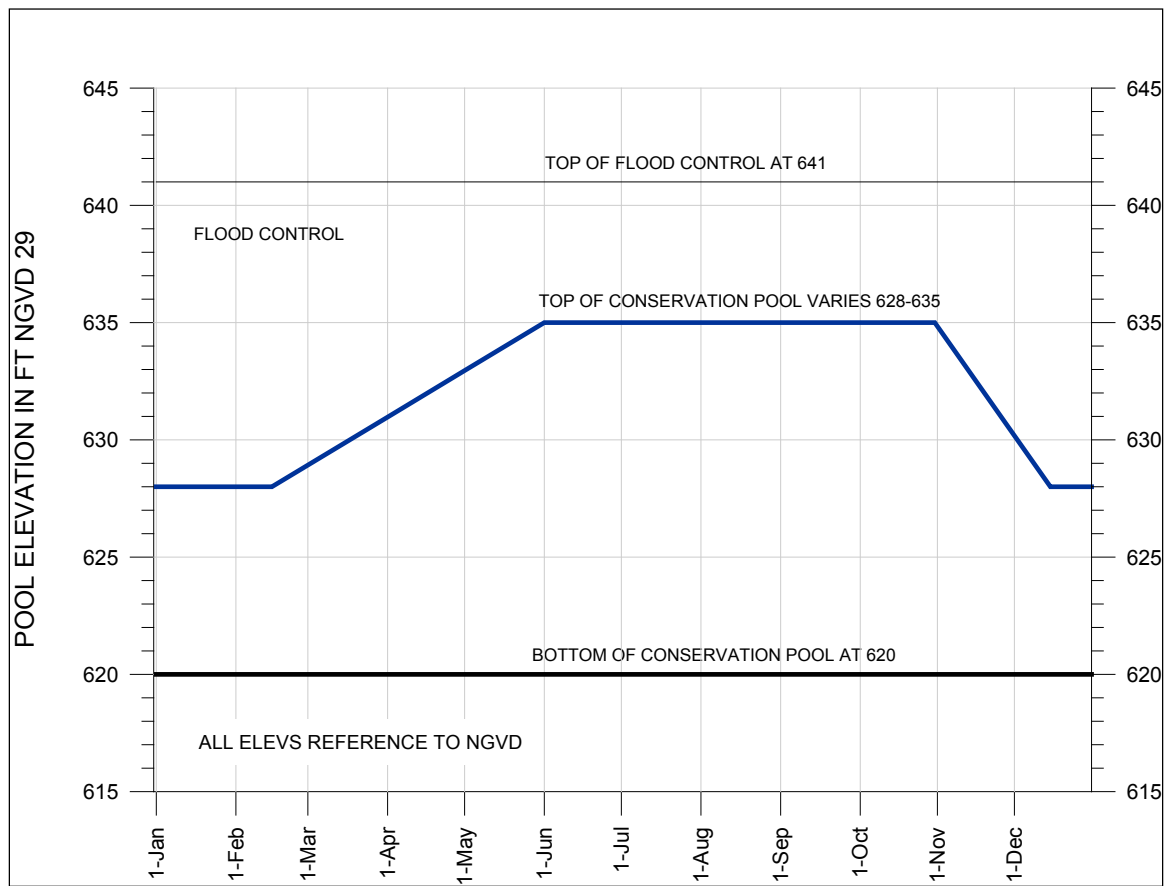


Figure B-22. Top and Bottom of West Point Conservation Pool

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.

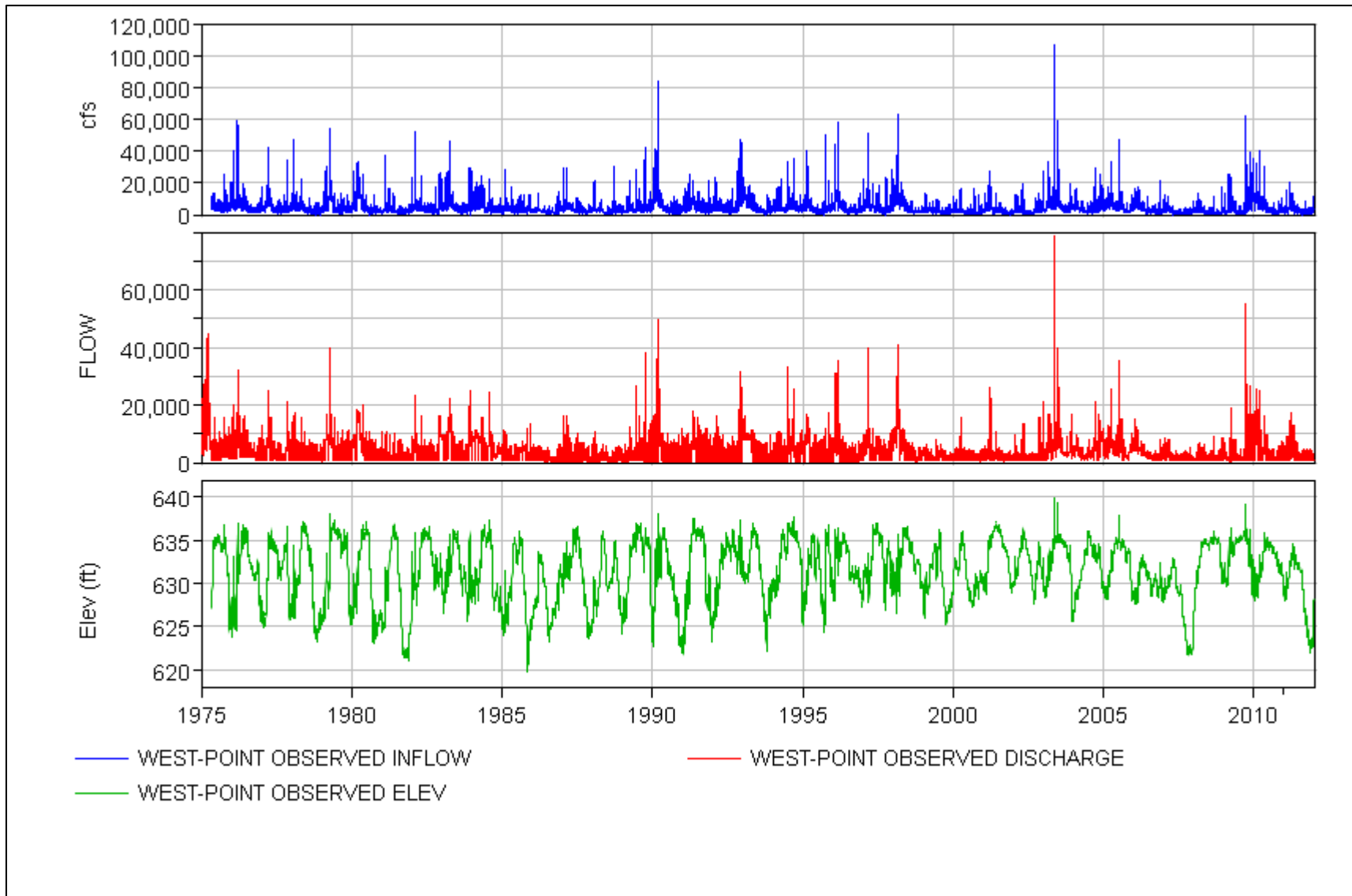


Figure B-23. West Point Inflow-Outflow-Pool Elevation (Jan 1975-Dec 2009)

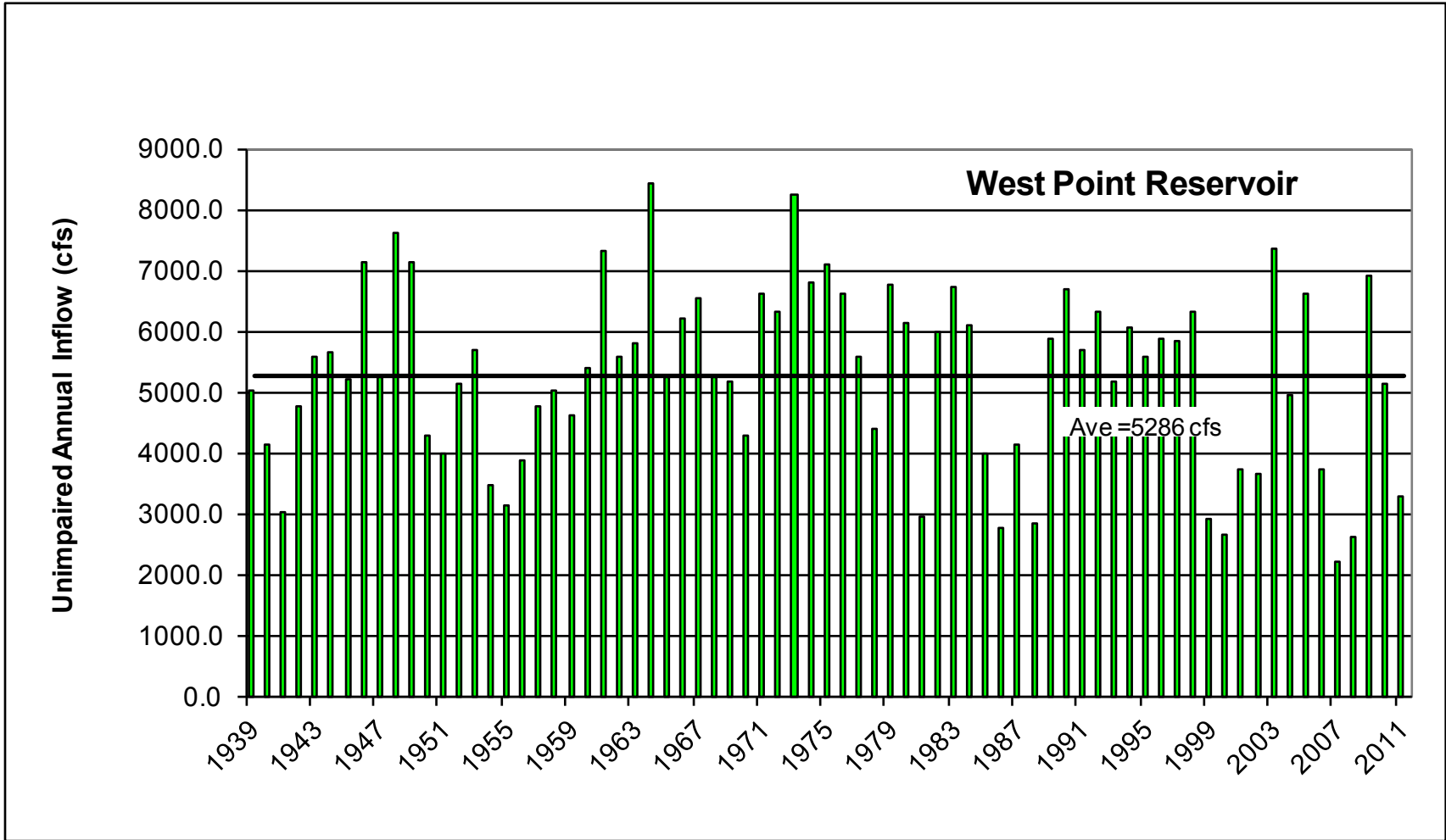


Figure B-24. West Point Unimpaired Annual Inflow Jan 1939 to Dec 2011

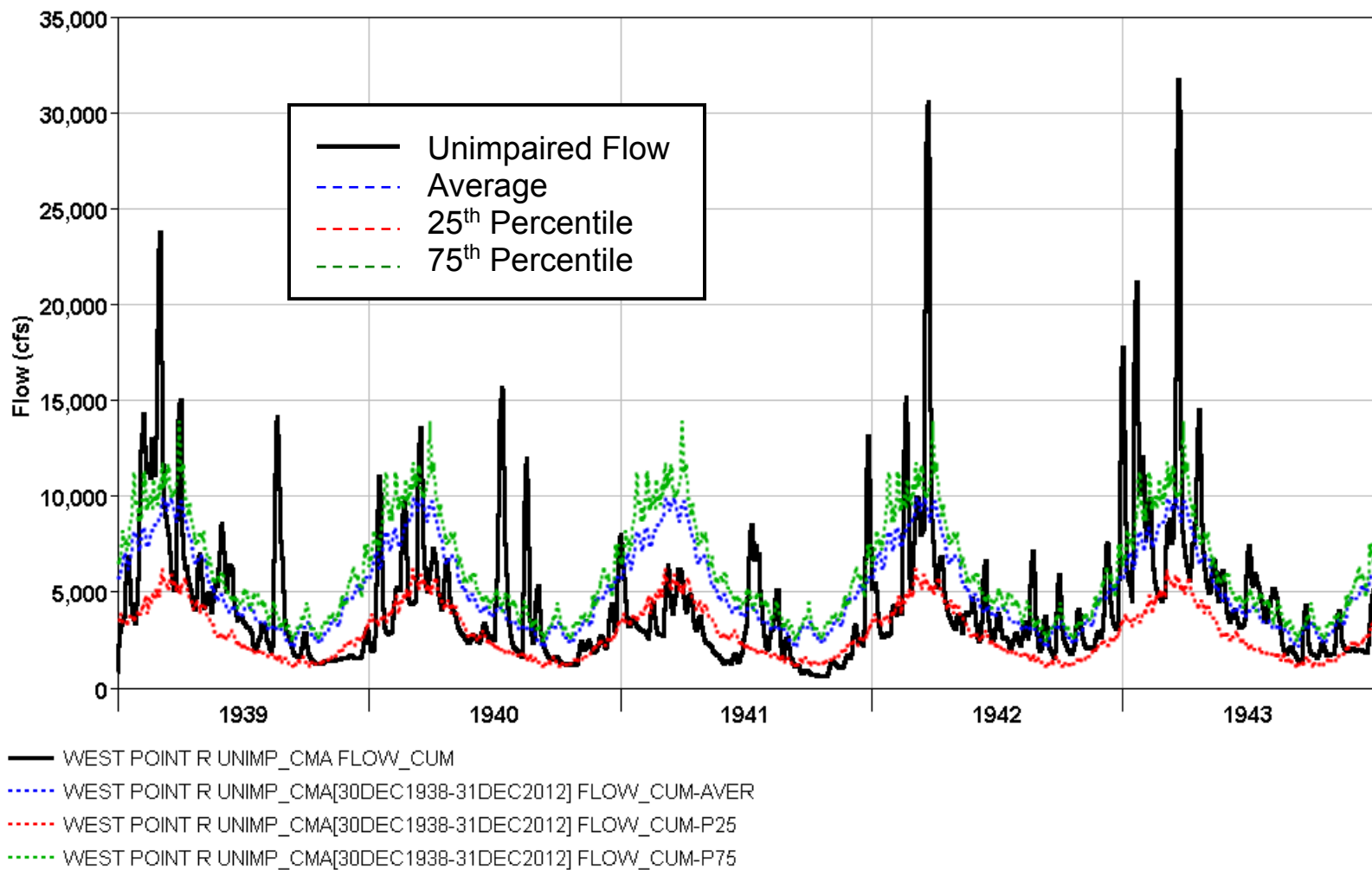


Figure B-25. West Point Unimpaired Inflow – 1940’s Drought; 75th Percentile, Average and 25th Percentile Flow

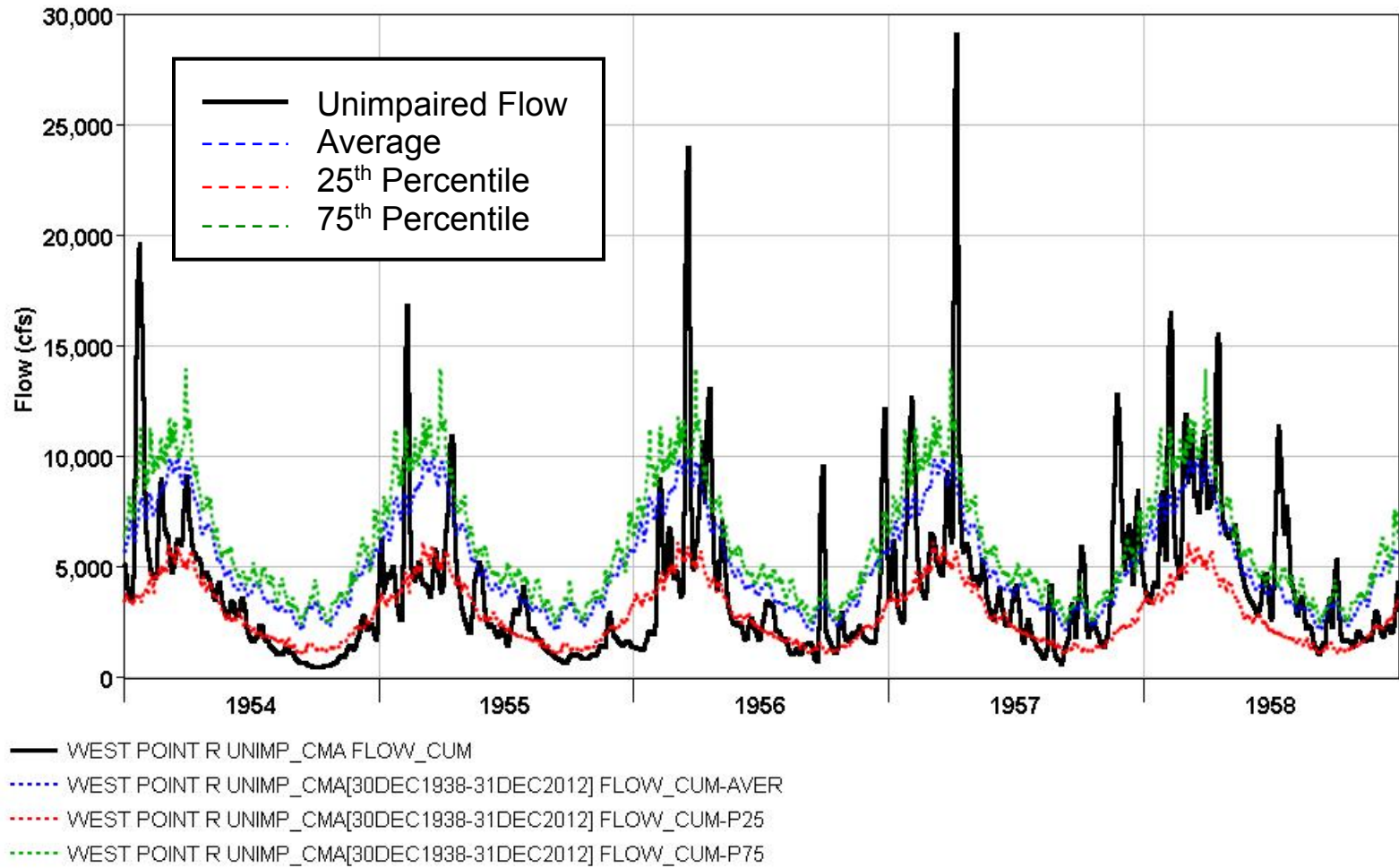


Figure B-26. West Point Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

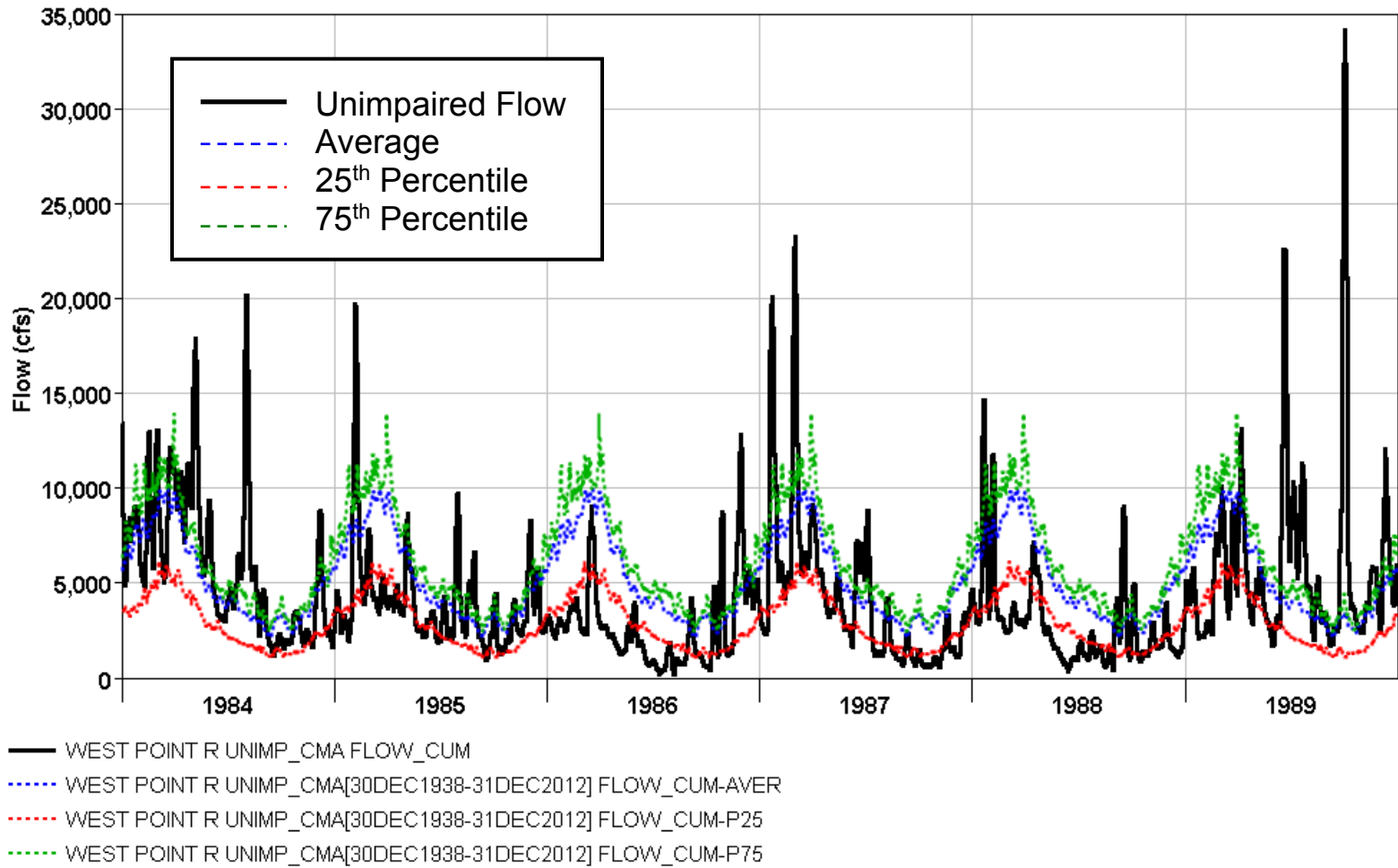


Figure B-27. West Point Unimpaired Inflow – 1980’s Drought; 75th Percentile, Average and 25th Percentile Flow

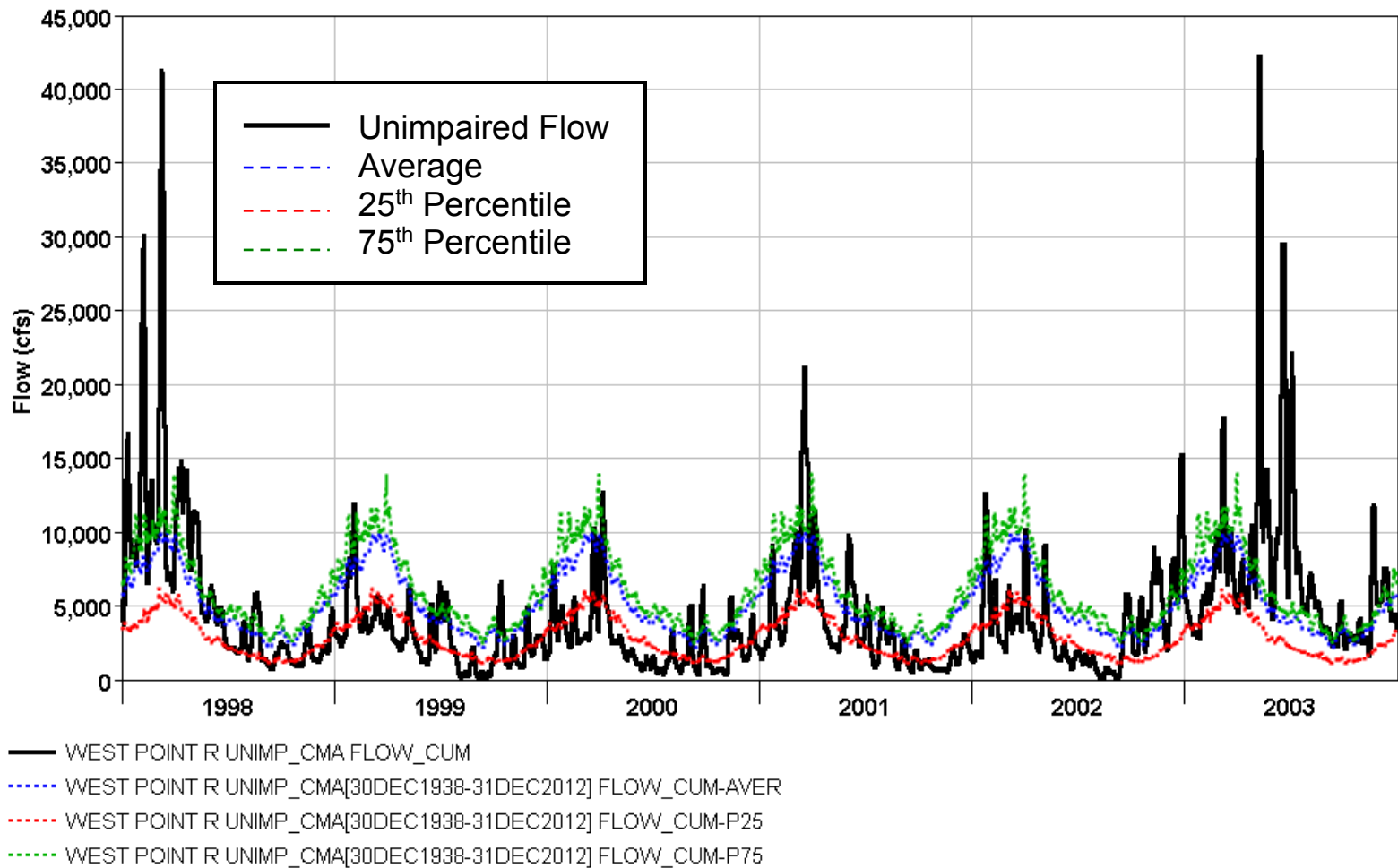


Figure B-28. West Point Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

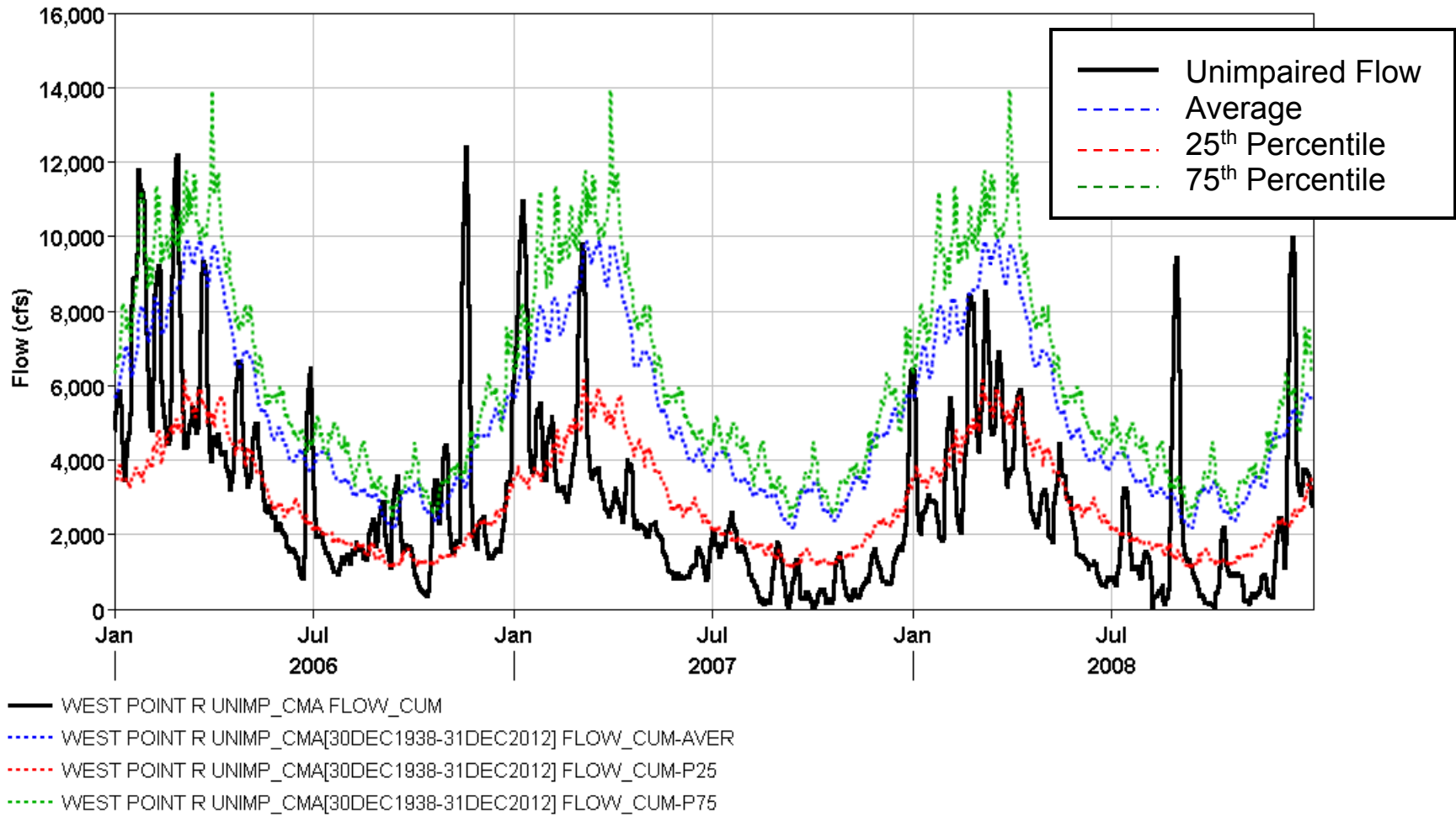


Figure B-29. West Point Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

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.

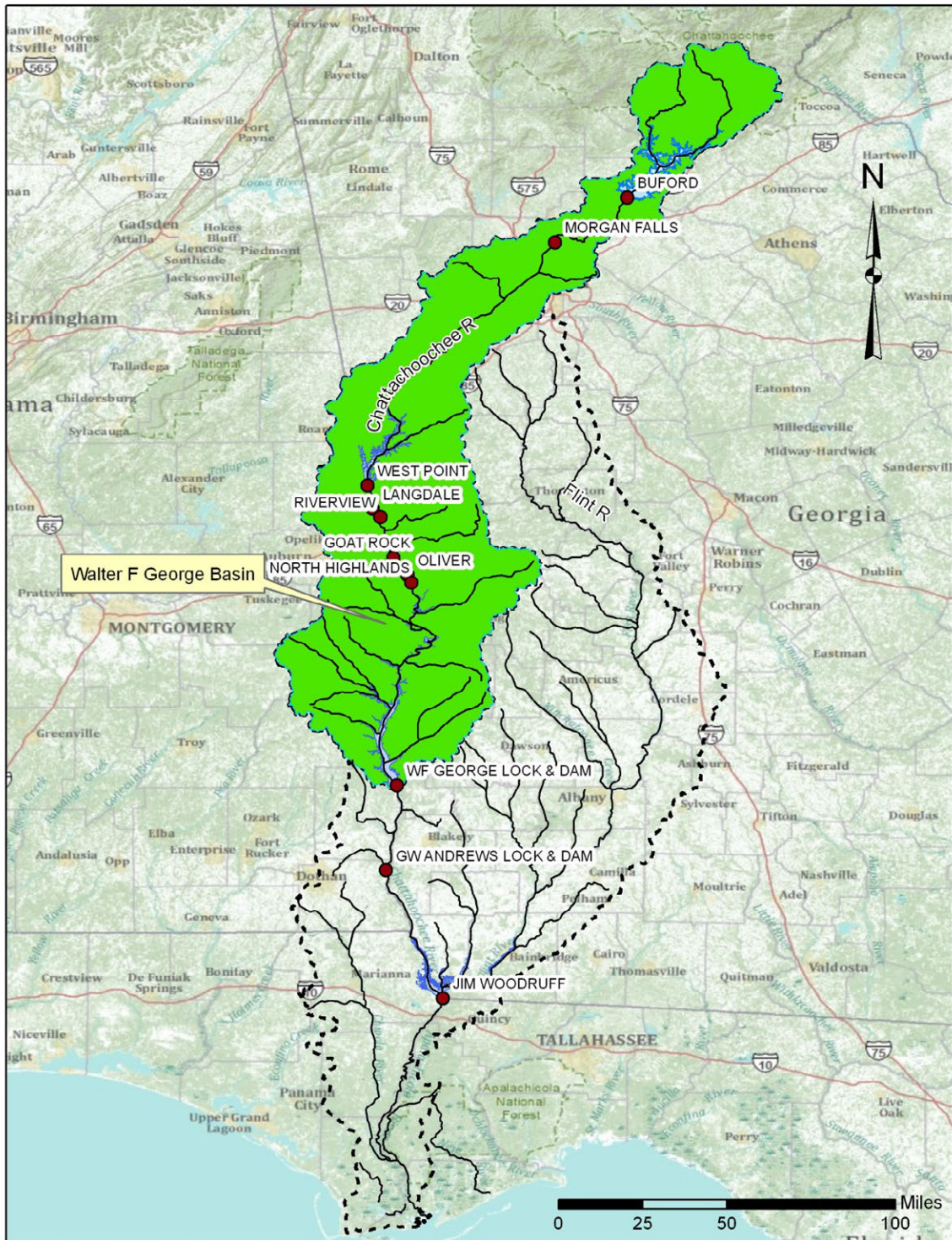


Figure B-31. Walter F. George Basin Map

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.

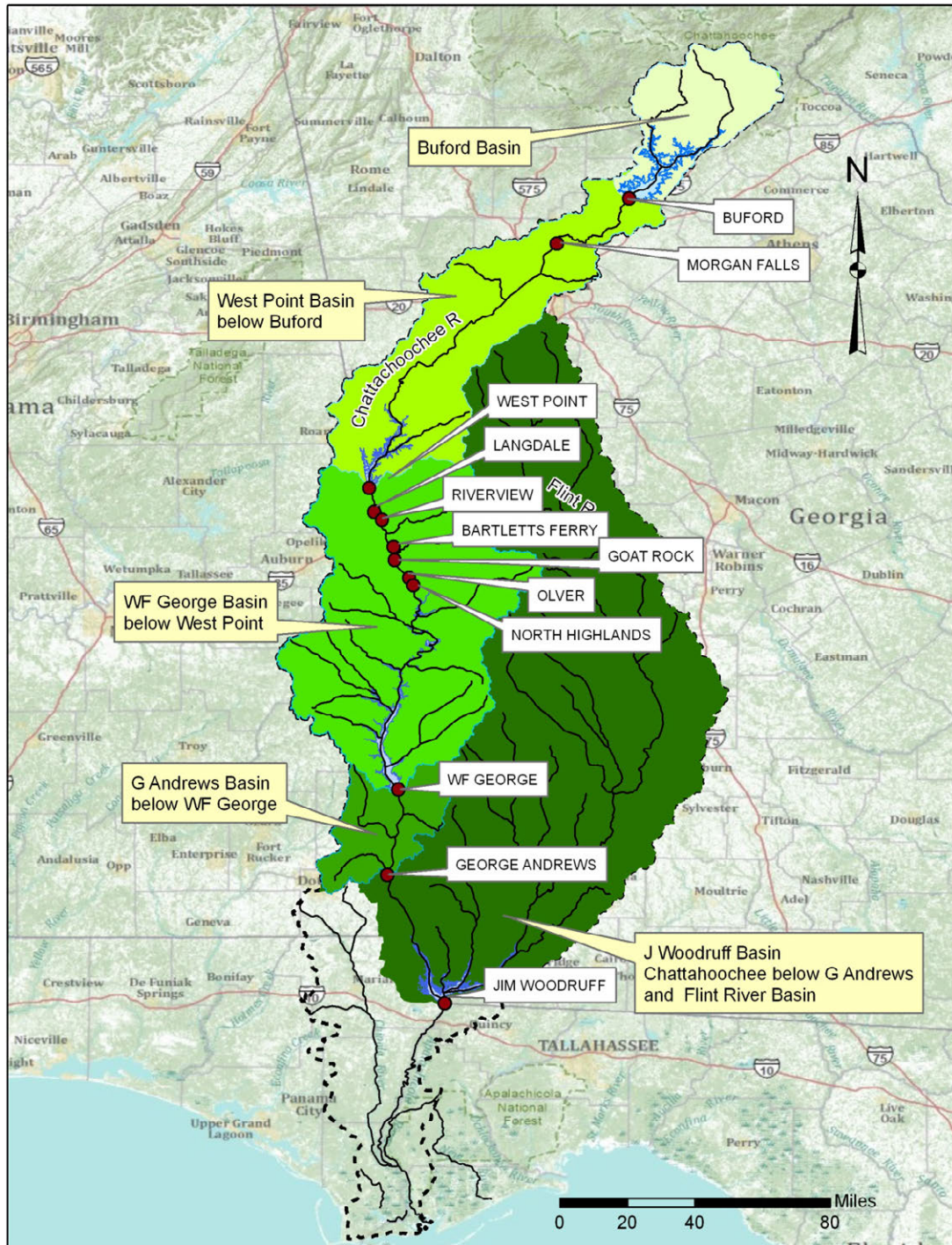


Figure B-32. Incremental Drainage Basin Map for Federal Projects on the ACF

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.

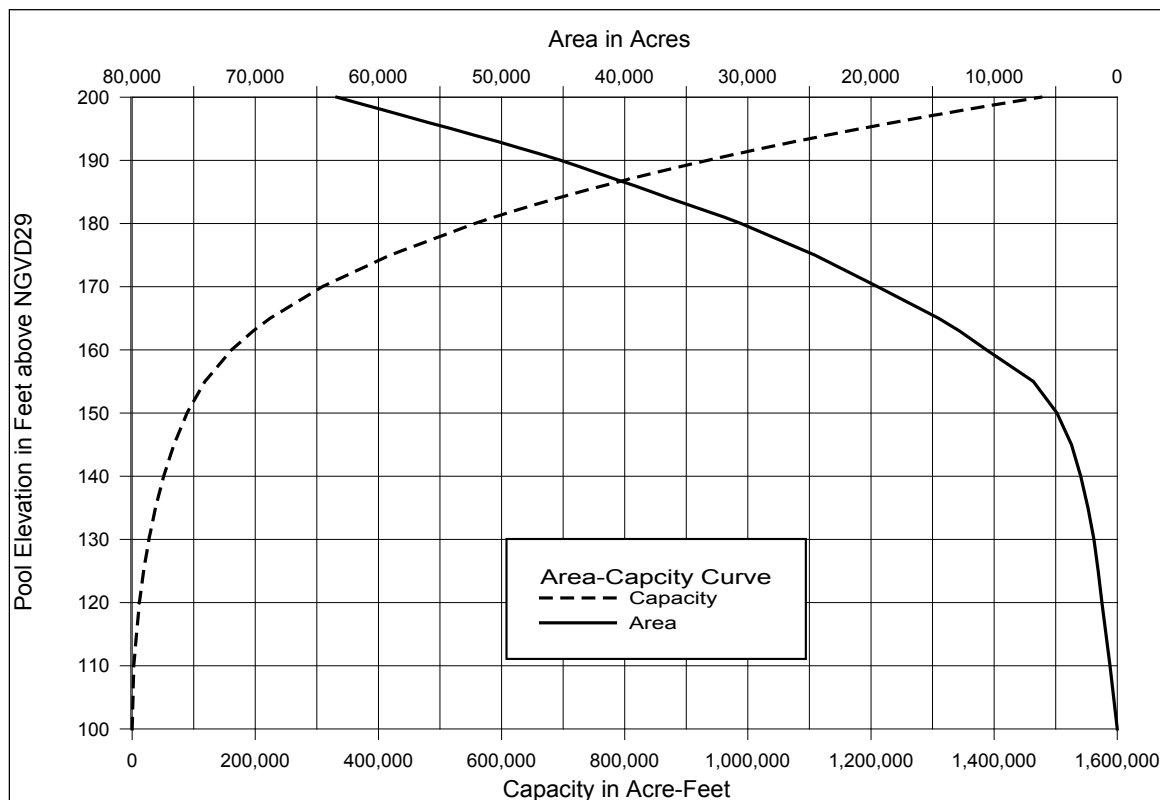


Figure B-33. Walter F. George Area – Capacity Curves (circa 1965)

Table B-7. Walter F. George Reservoir Area and Capacity (circa 1965)

Pool Elev	Total Area	Total Storage
(ft NGVD 29)	(ac)	(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 until 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.

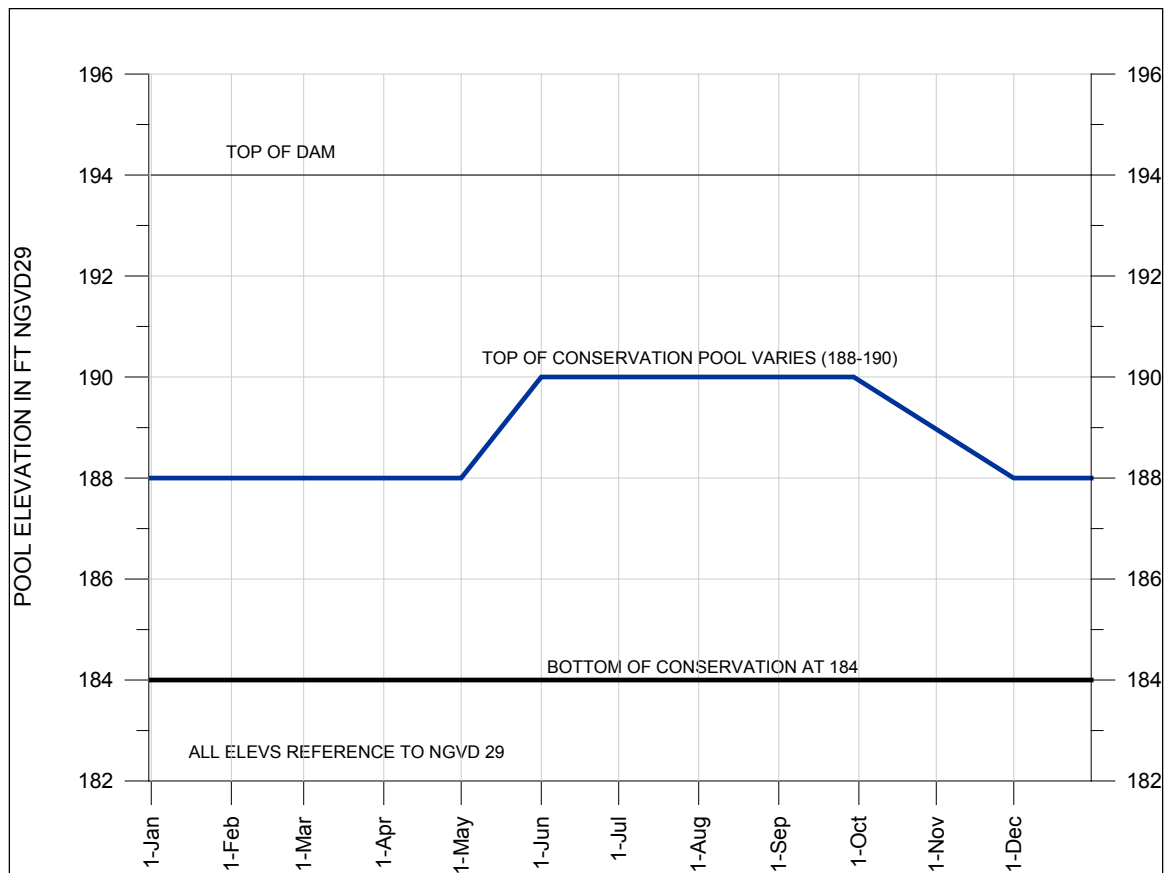


Figure B-34. Top and Bottom of Walter F. George Conservation Pool

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.

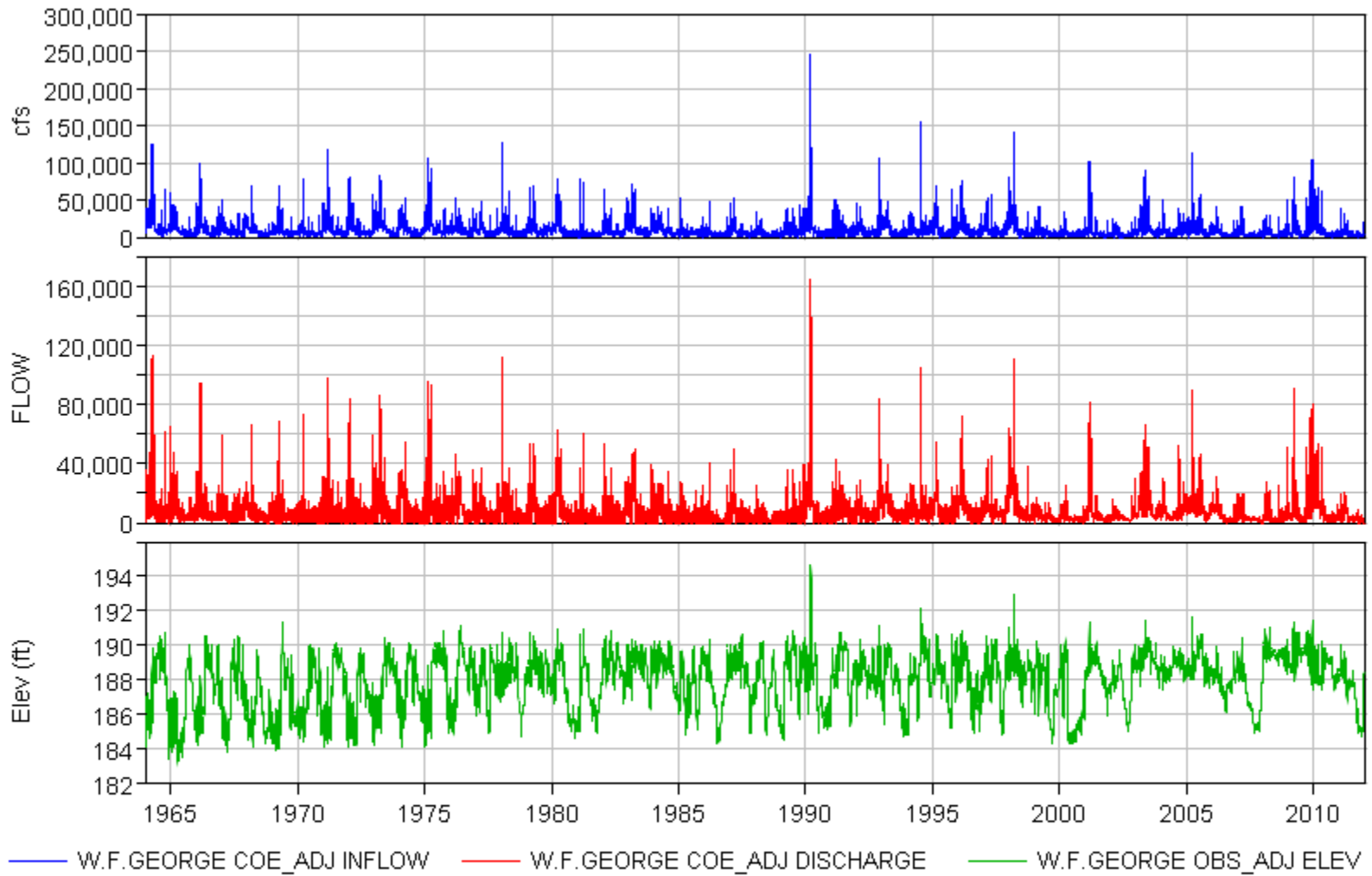


Figure B-35. Walter F. George Inflow-Outflow-Pool Elevation (Jan 1964-Dec 2011)

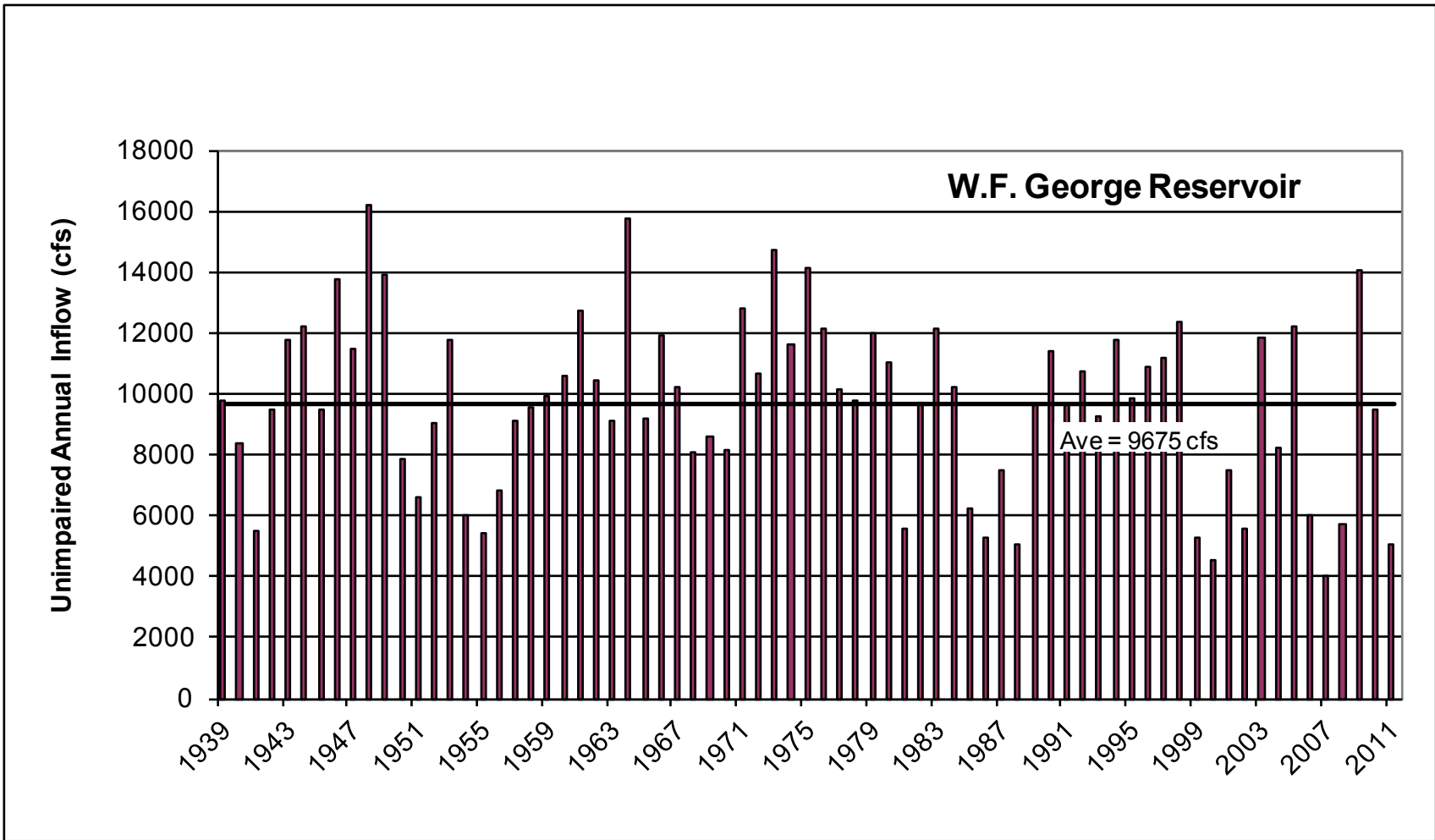


Figure B-36. Walter F. George Unimpaired Annual Inflow Jan 1939 to Dec 2011

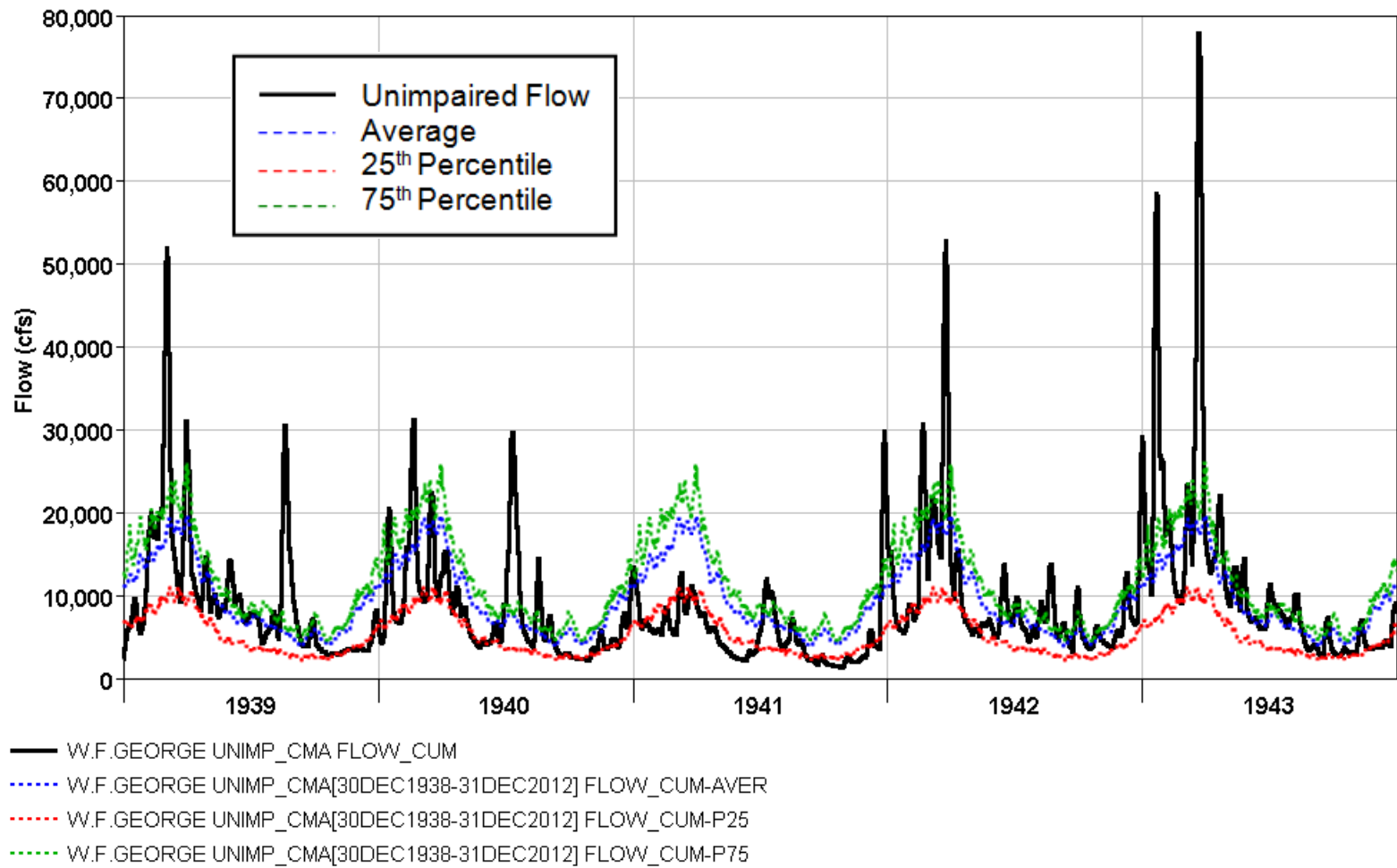


Figure B-37. Walter F. George Unimpaired Inflow – 1940's Drought; 75th Percentile, Average and 25th Percentile Flow

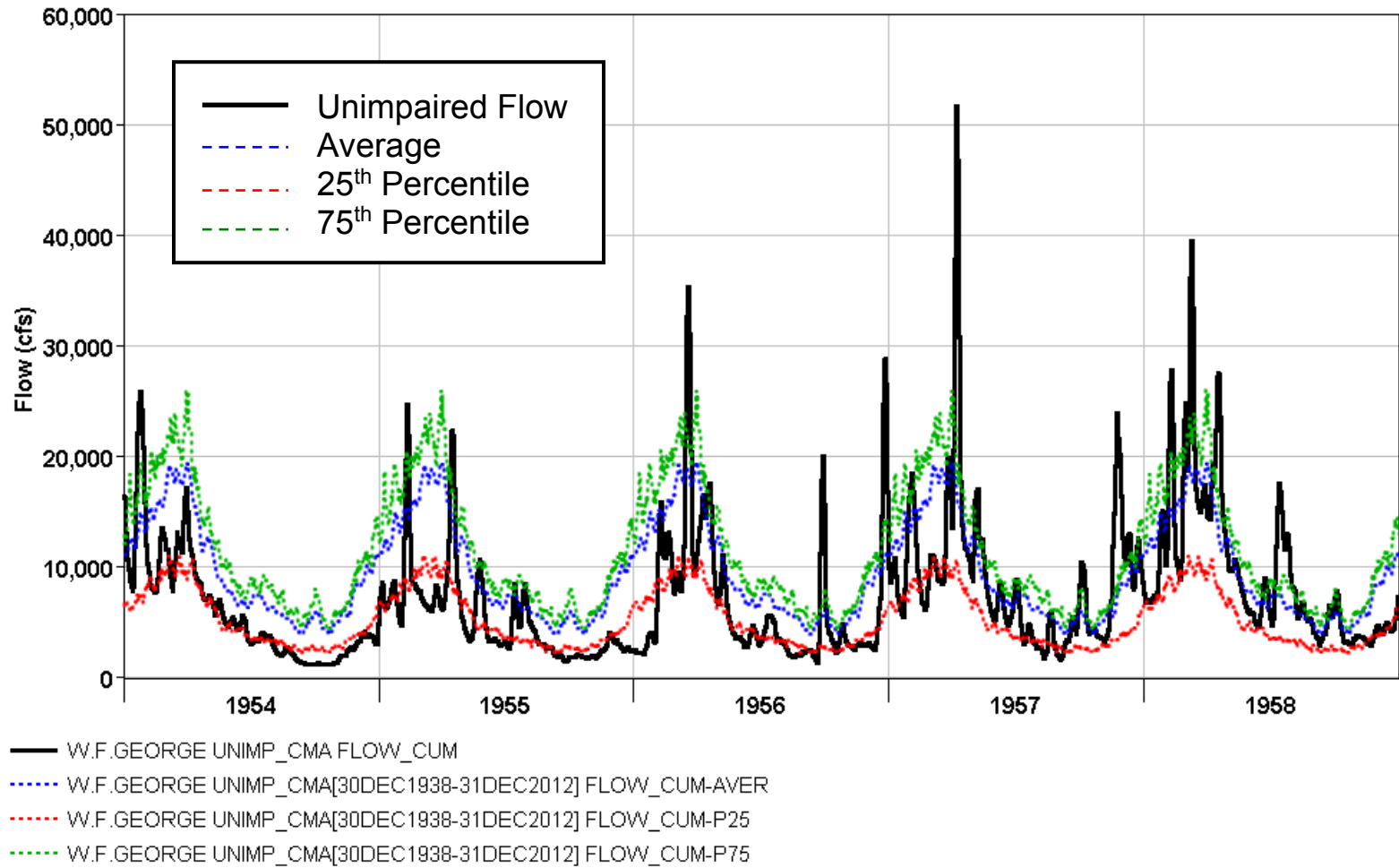


Figure B-38. Walter F. George Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

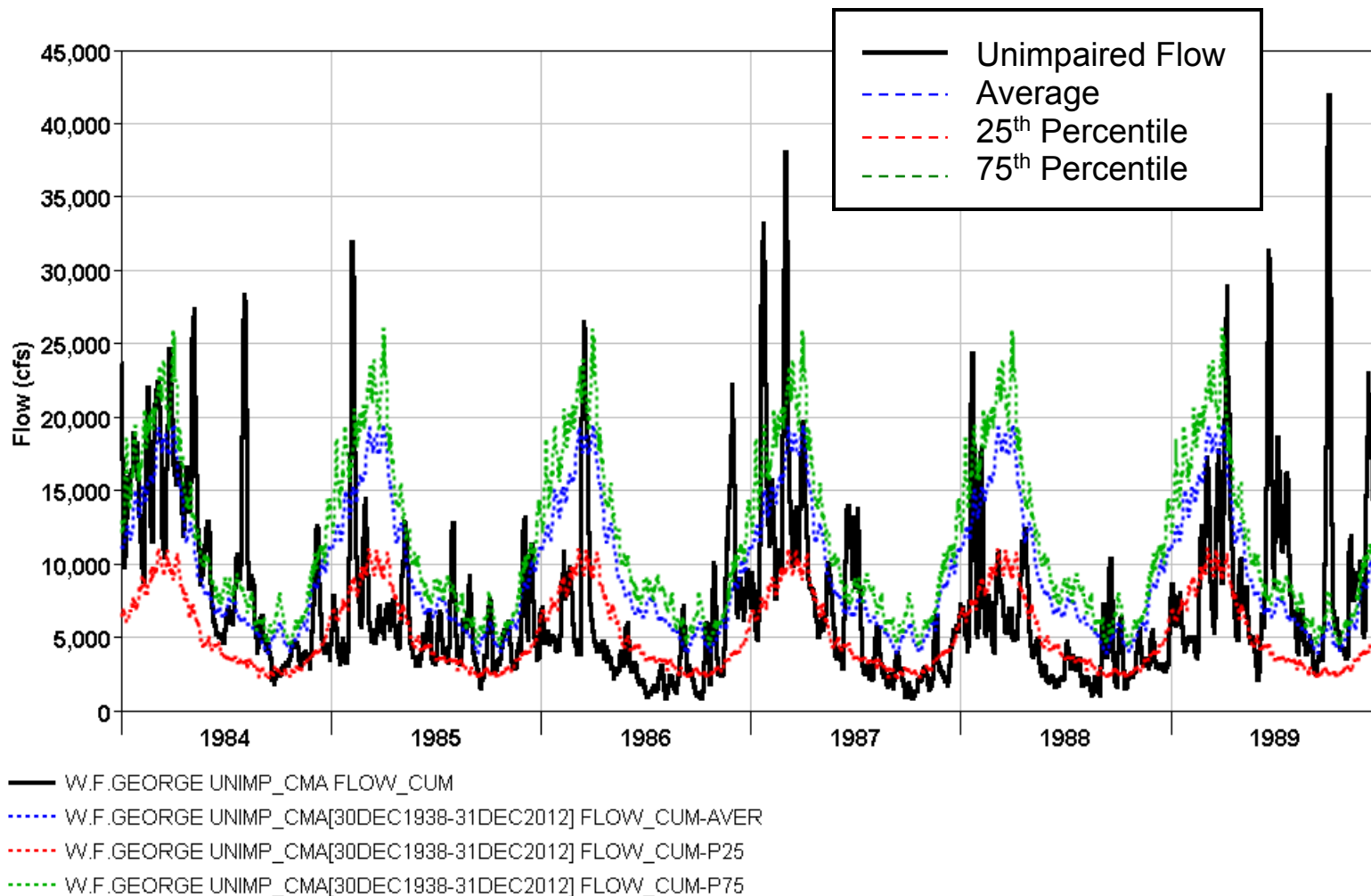


Figure B-39. Walter F. George Unimpaired Inflow – 1980’s Drought; 75th Percentile, Average and 25th Percentile Flow

B-50

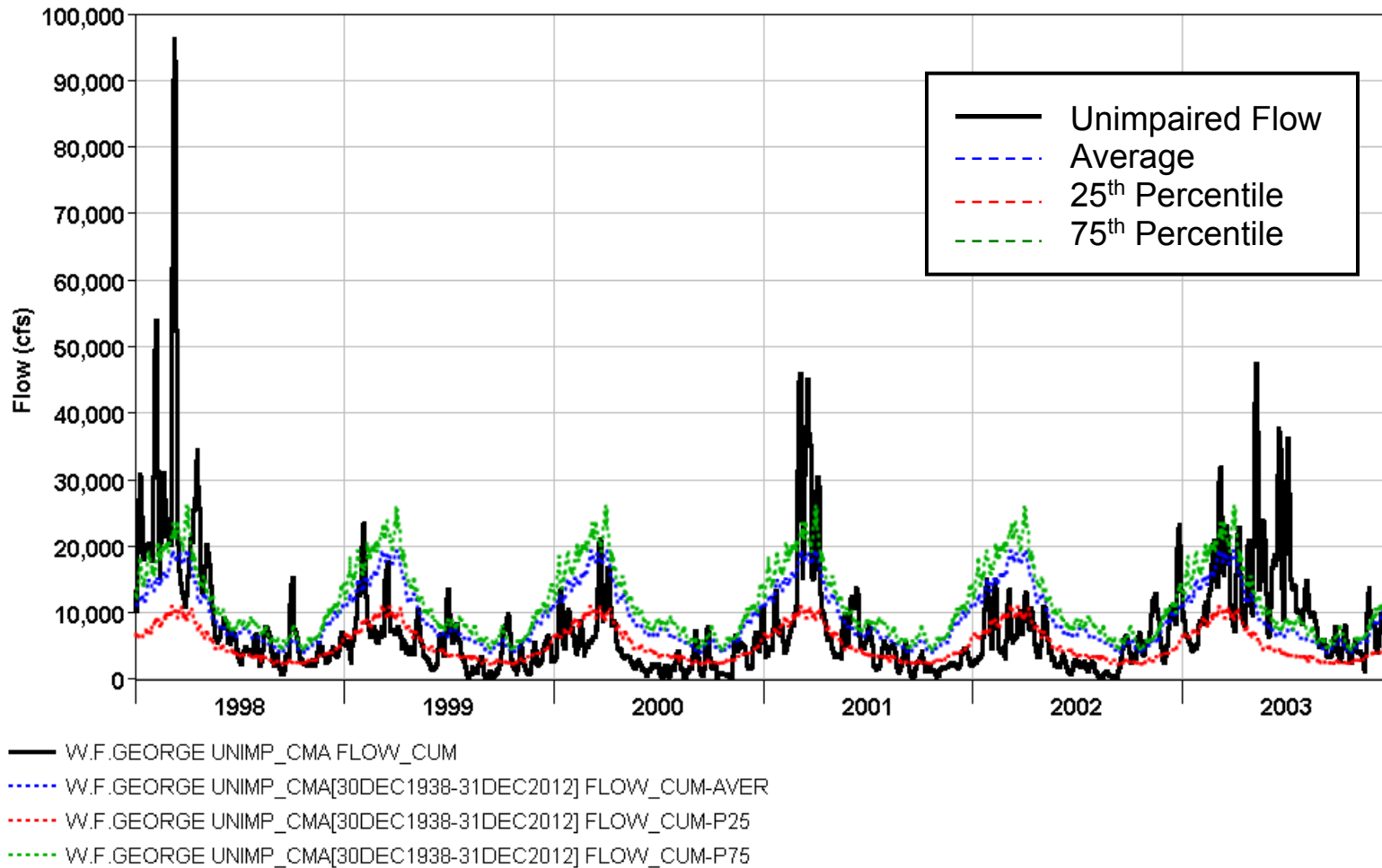


Figure B-40. Walter F. George Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

B-51

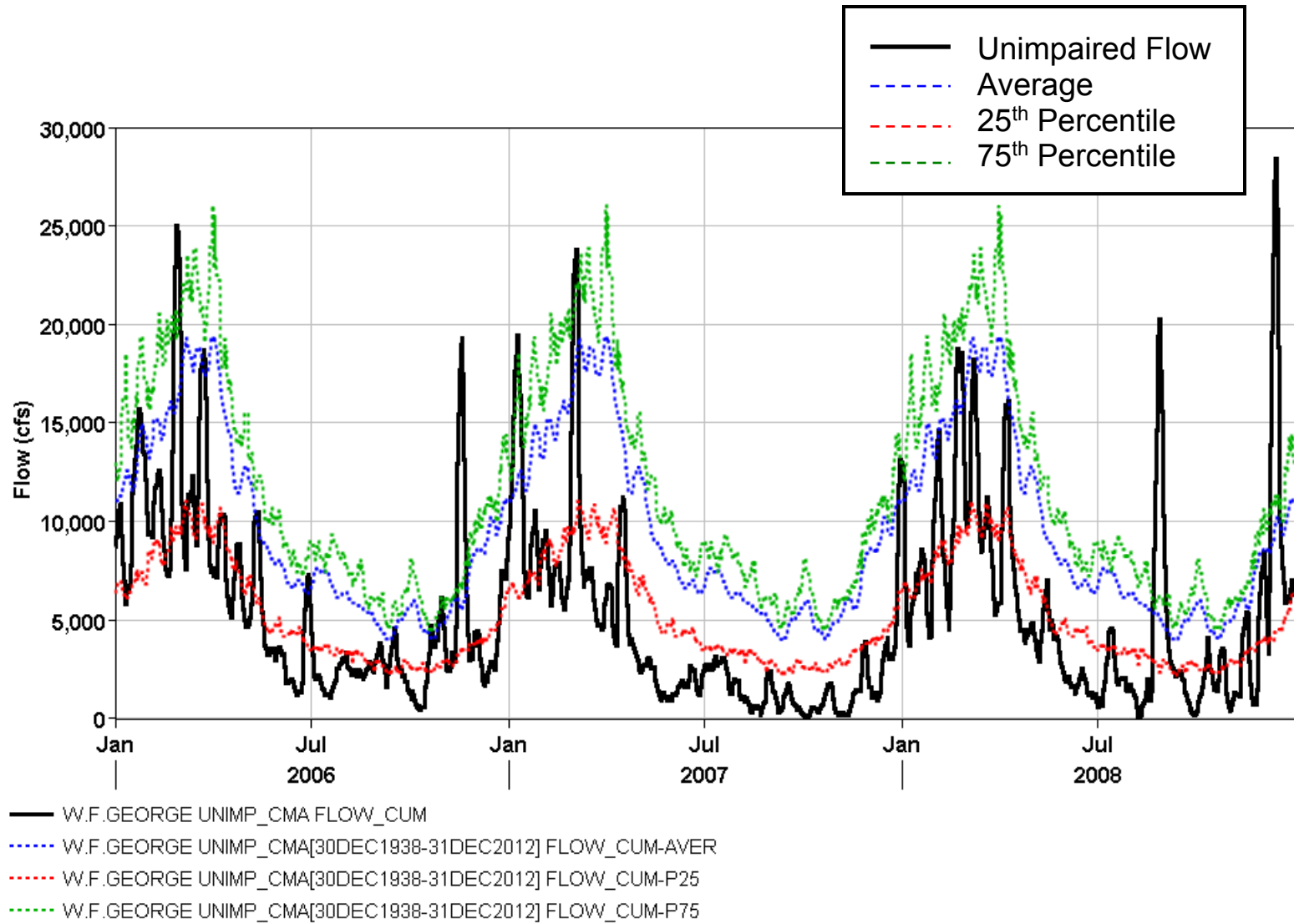


Figure B-41. Walter F. George Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

1.6 ResSim MODELING

The ResSim model for the ACF Basin is shown below in Figure B-42.

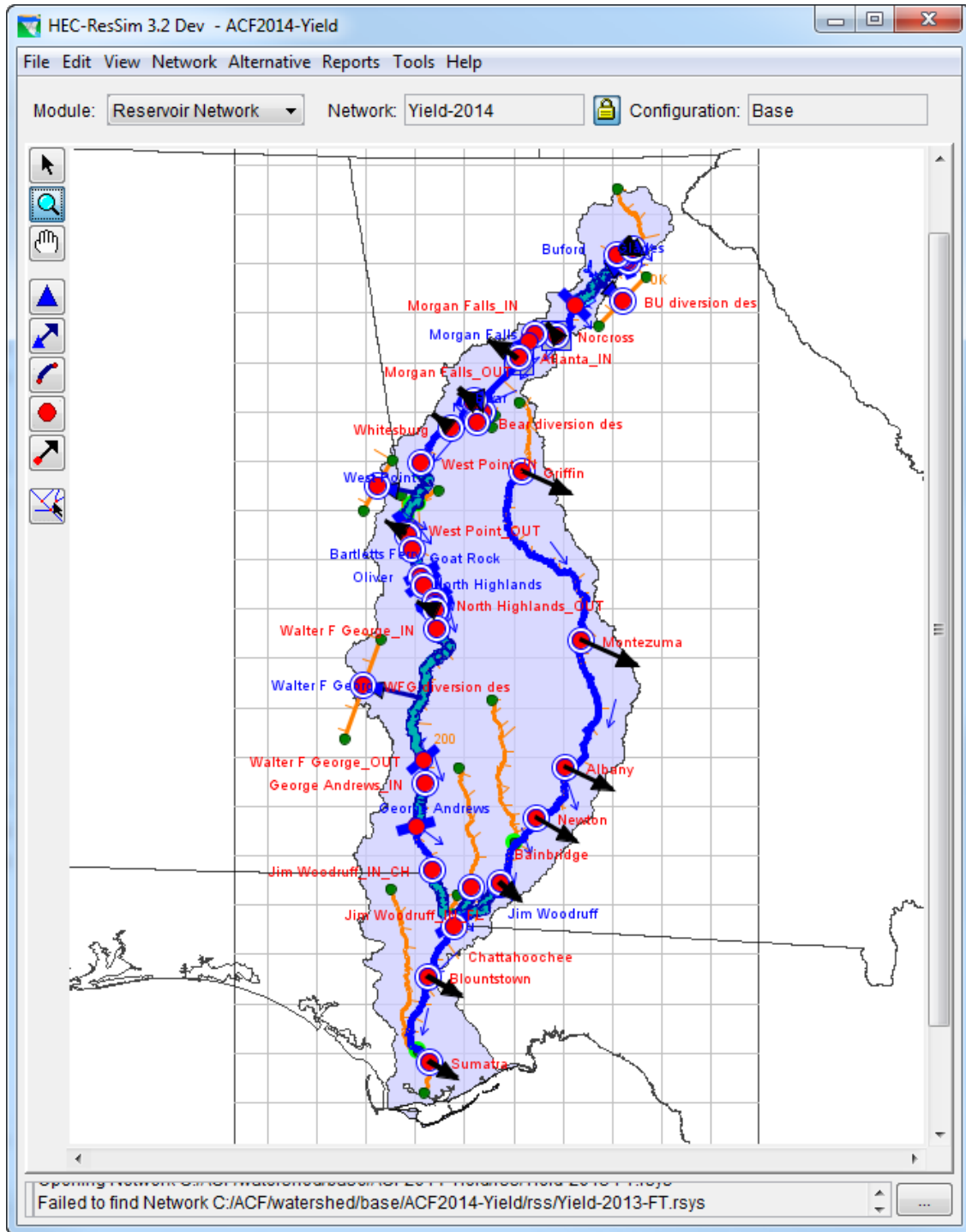


Figure B-42. ACF ResSim Model Schematic

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

Project	Drought Period					Critical Period
	1940	1950	1980	2000	2007	
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

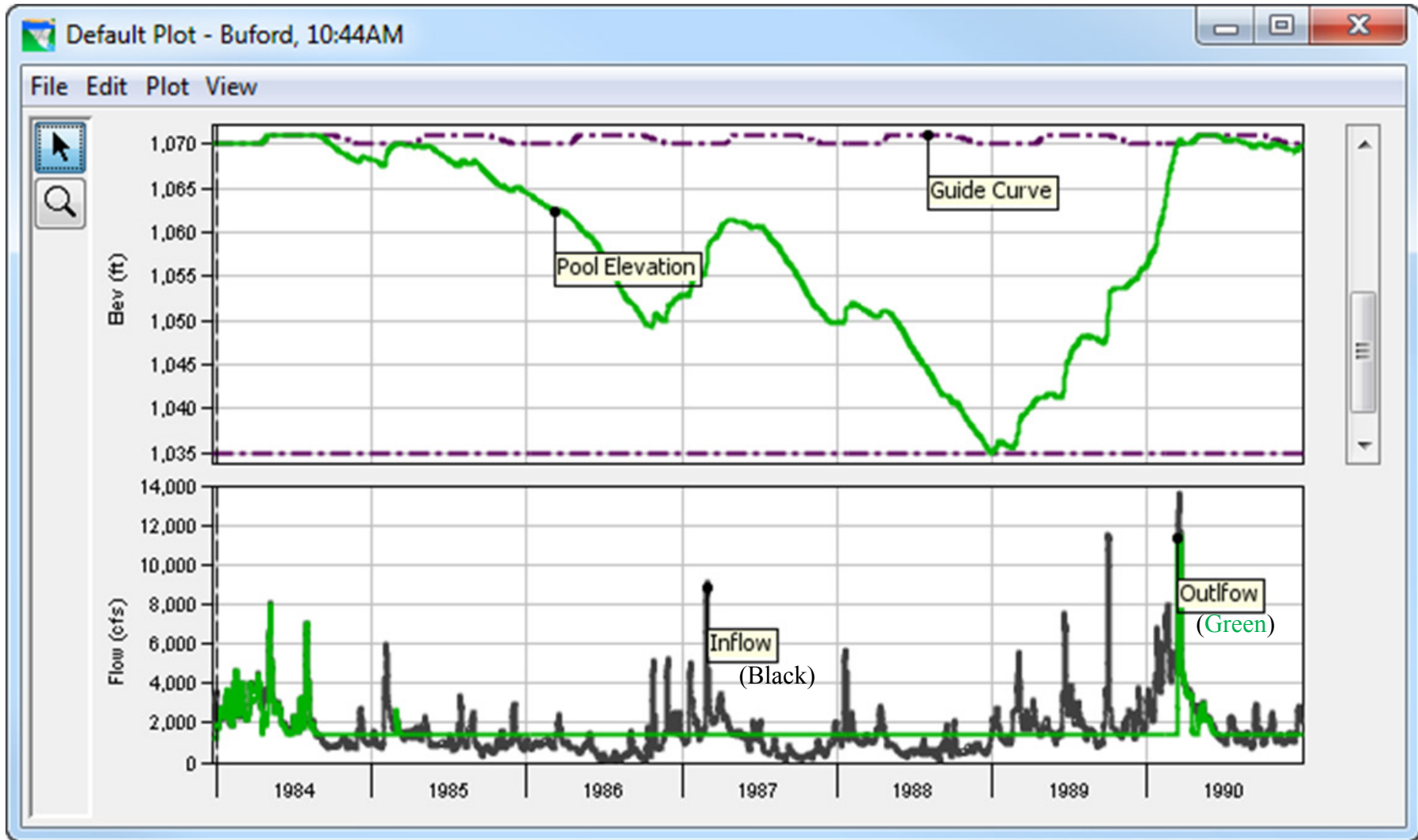


Figure B-43. Buford Critical Yield Result, Method A (No Diversions)

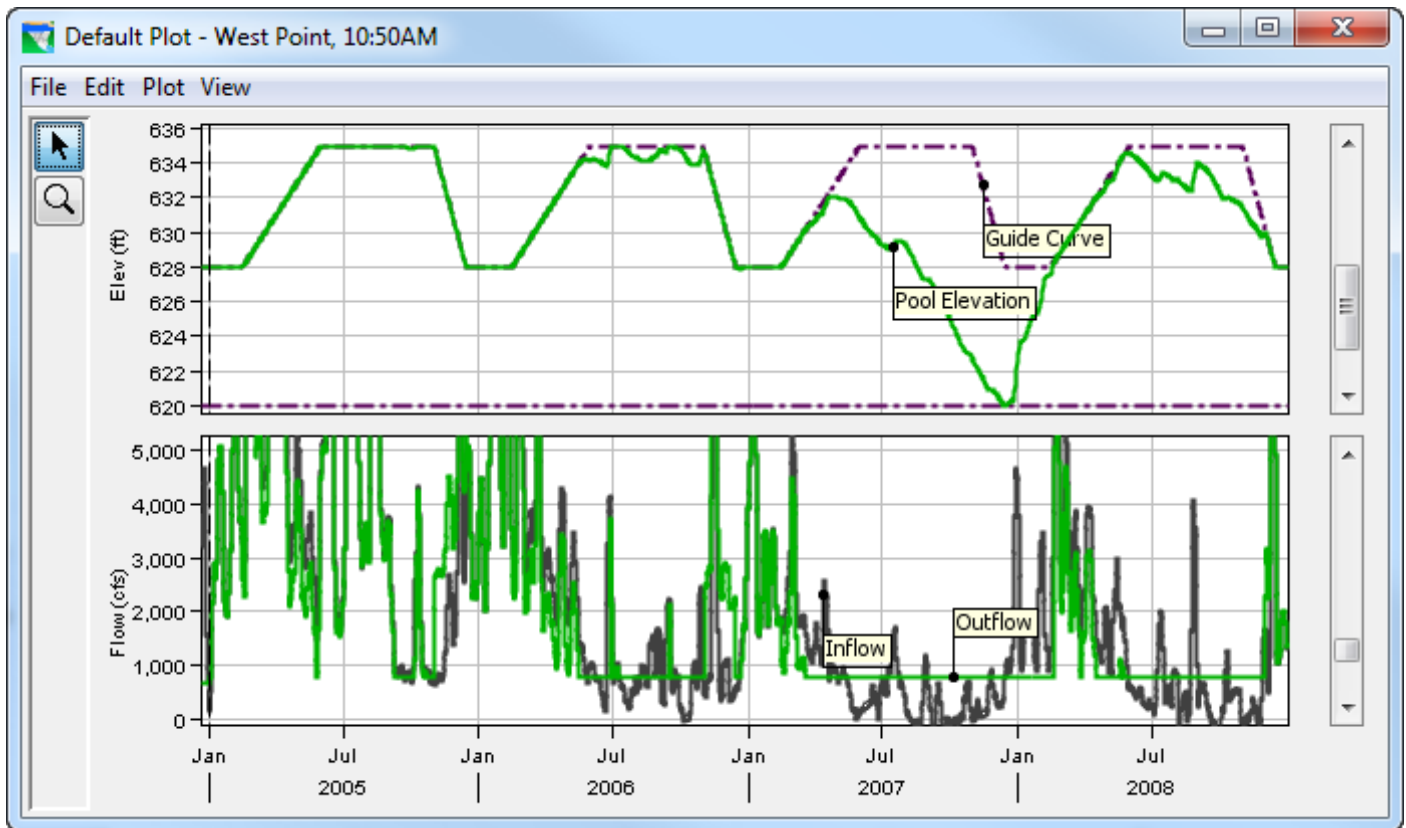


Figure B-44. West Point Critical Yield Result, Method A (No Diversions)

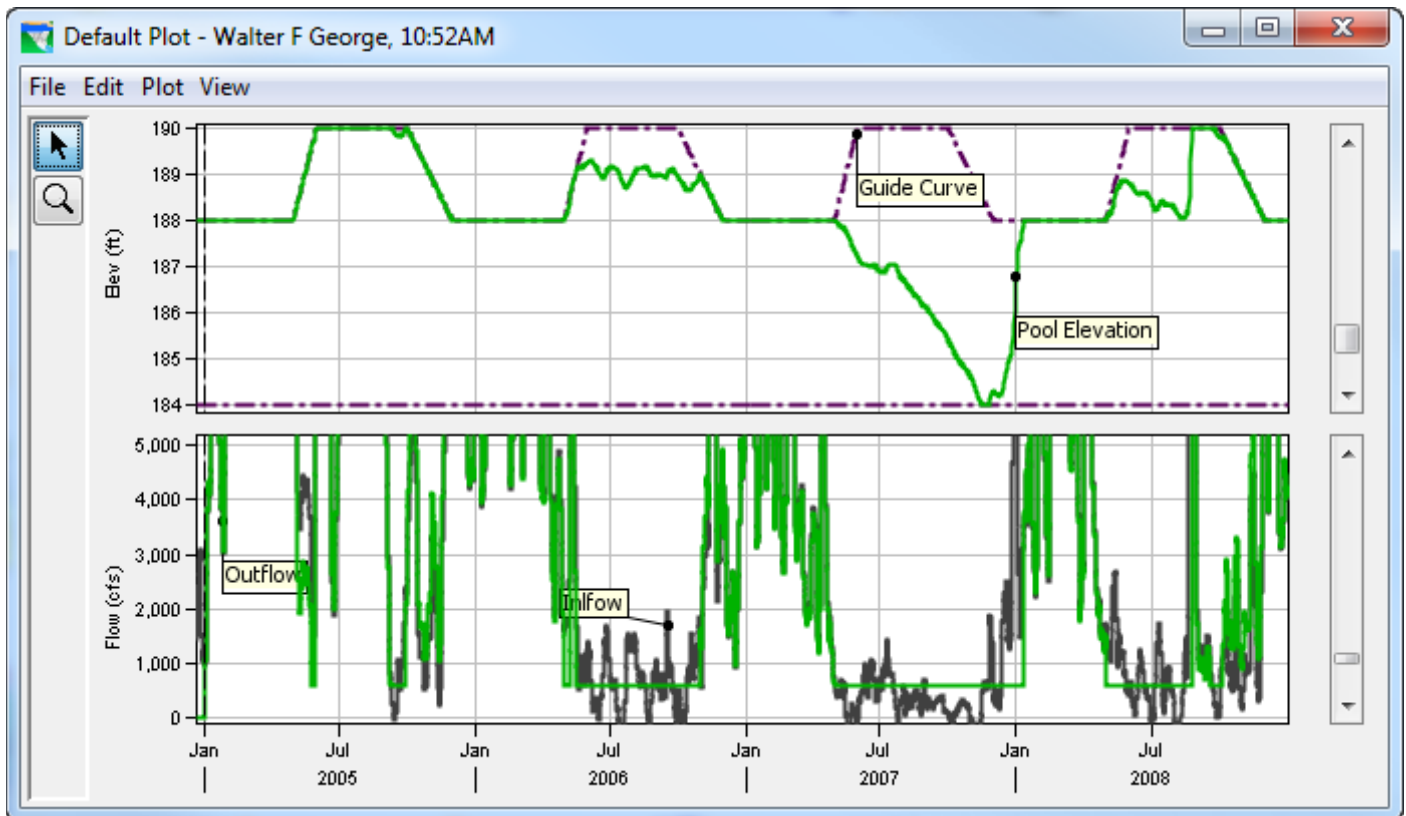


Figure B-45. Walter F. George Critical Yield Result, Method A (No Diversions)

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

Project	Drought Period					Critical Period
	1940	1950	1980	2000	2007	
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

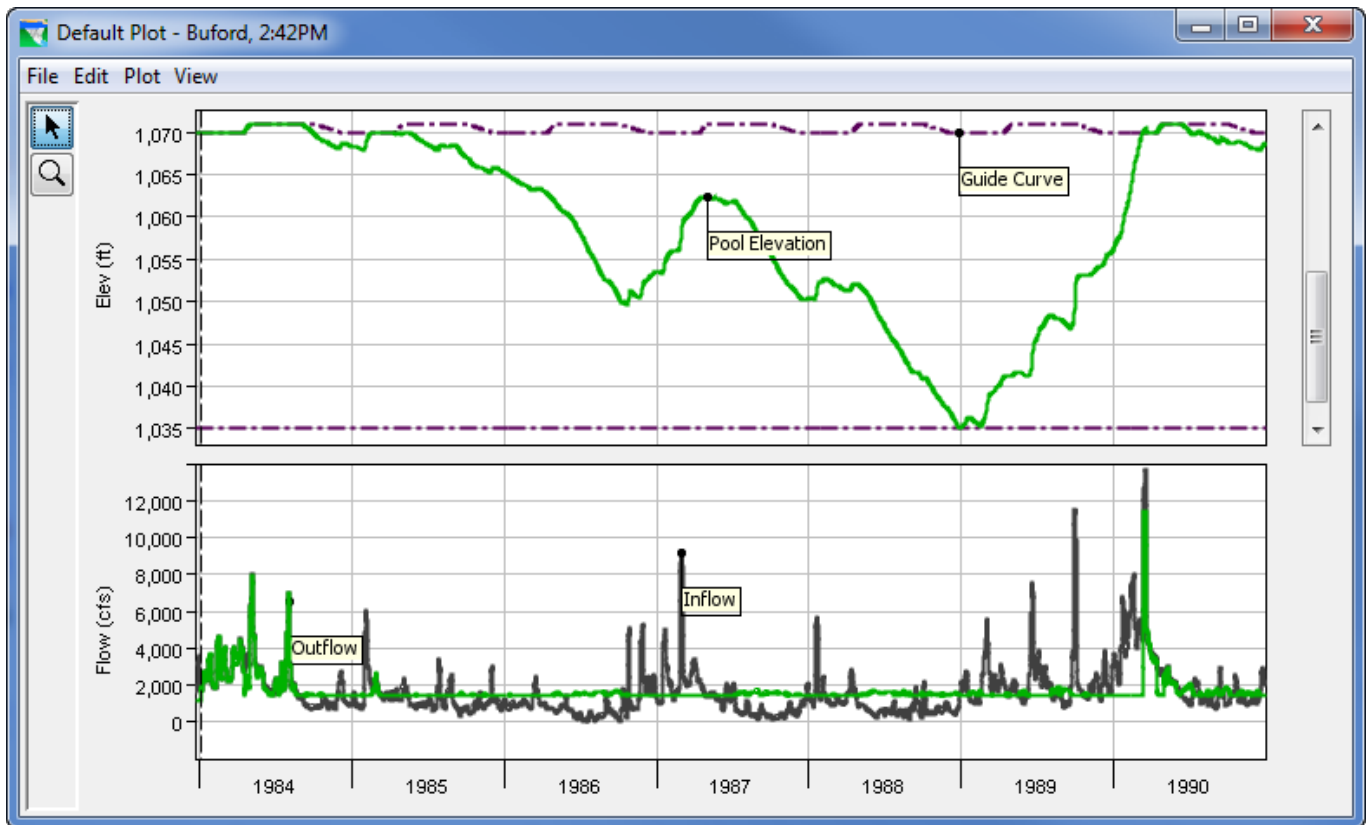


Figure B-46. Buford Critical Yield Result, Method B (With Diversions)

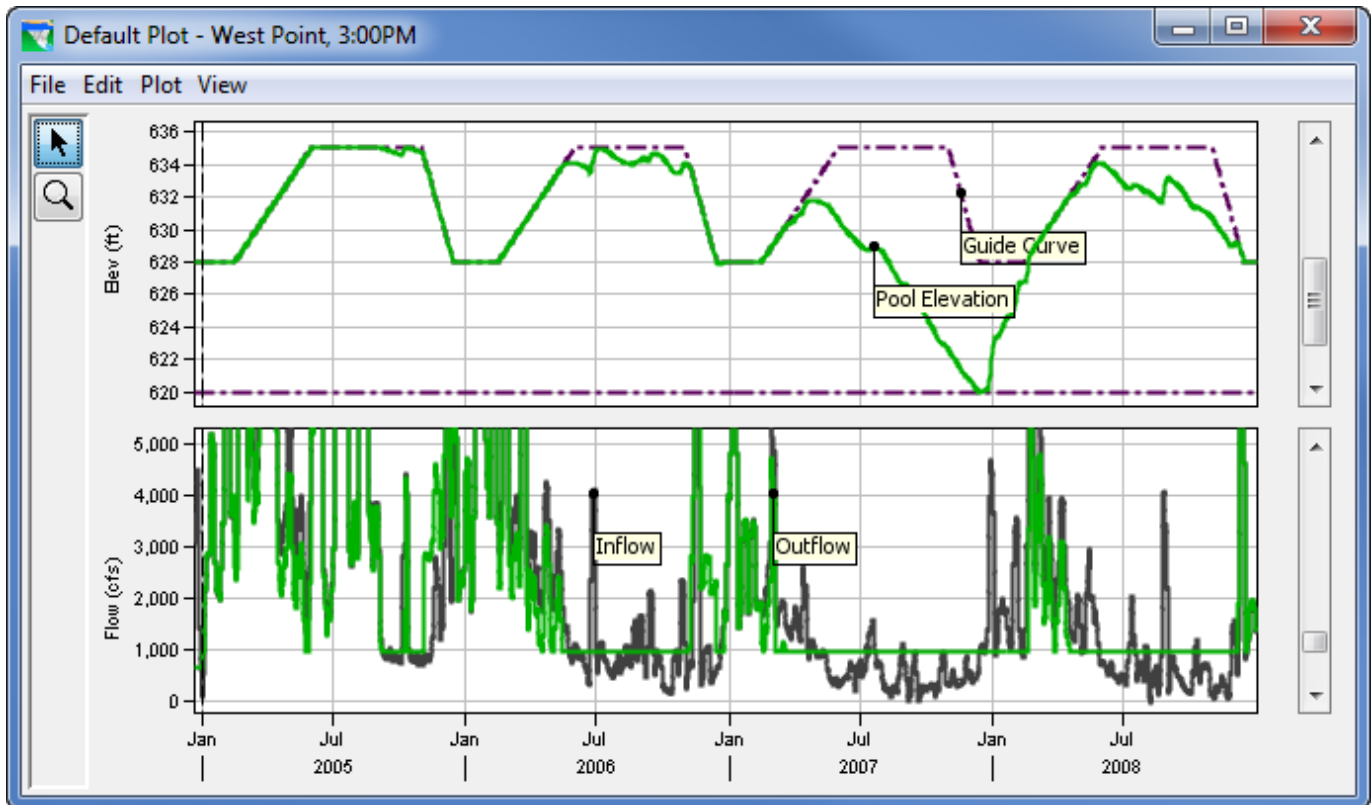


Figure B-47. West Point Critical Yield Result, Method B (With Diversions)

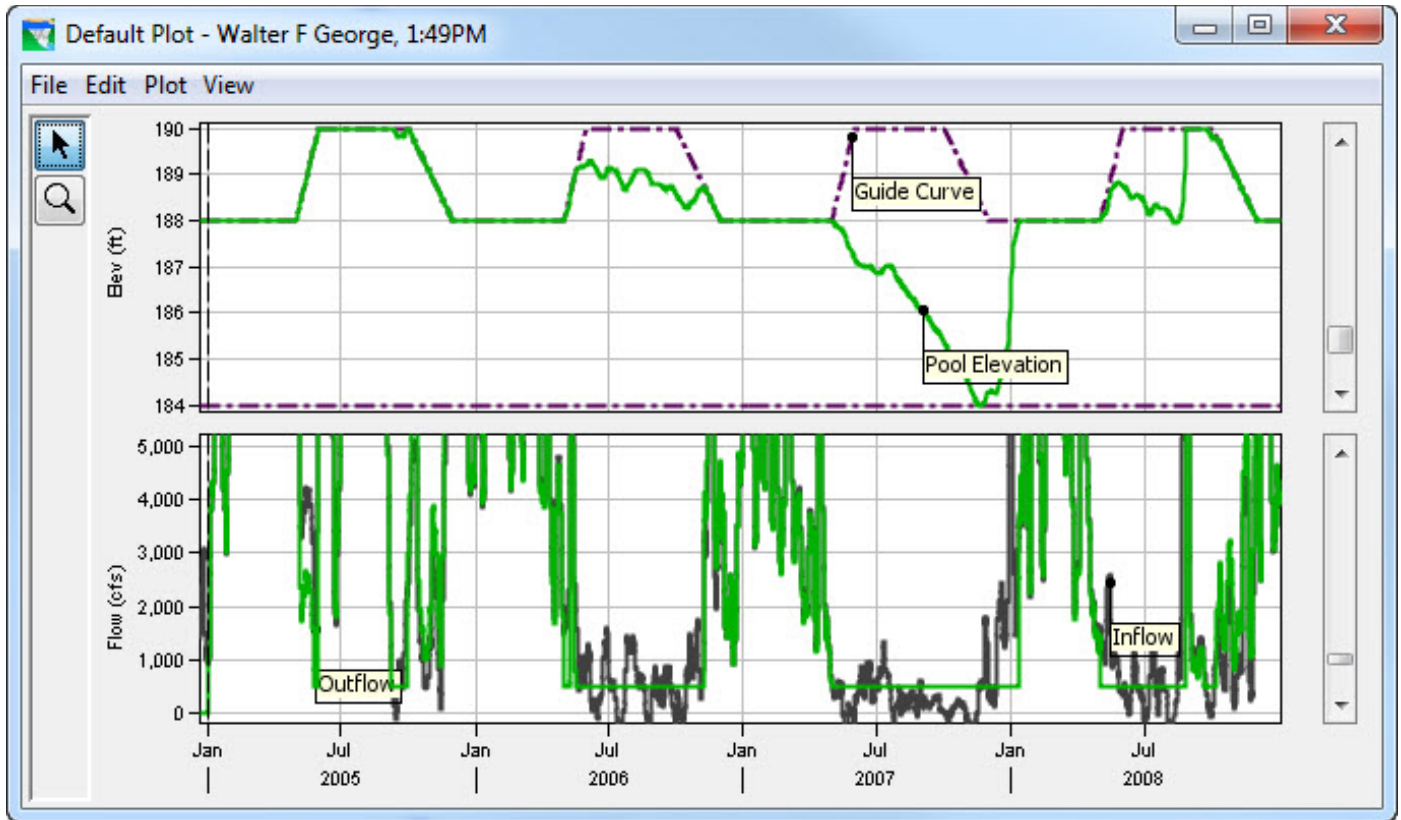


Figure B-48. Walter F. George Critical Yield Result, Method B (With Diversions)

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

Project	Drought Period					Critical Period
	1940	1950	1980	2000	2007	
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 I 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

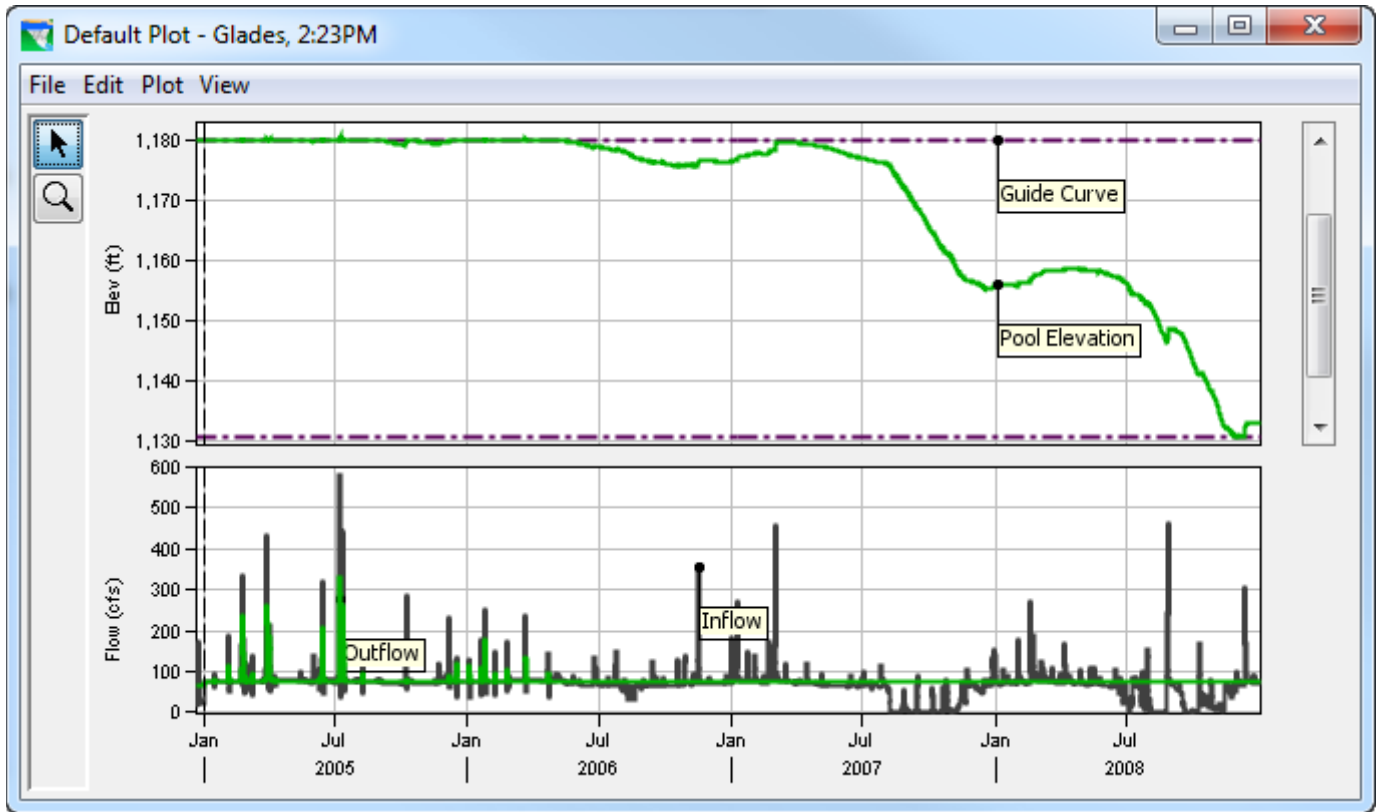


Figure B-49. Glades Critical Yield Result, Method B (With Diversions)

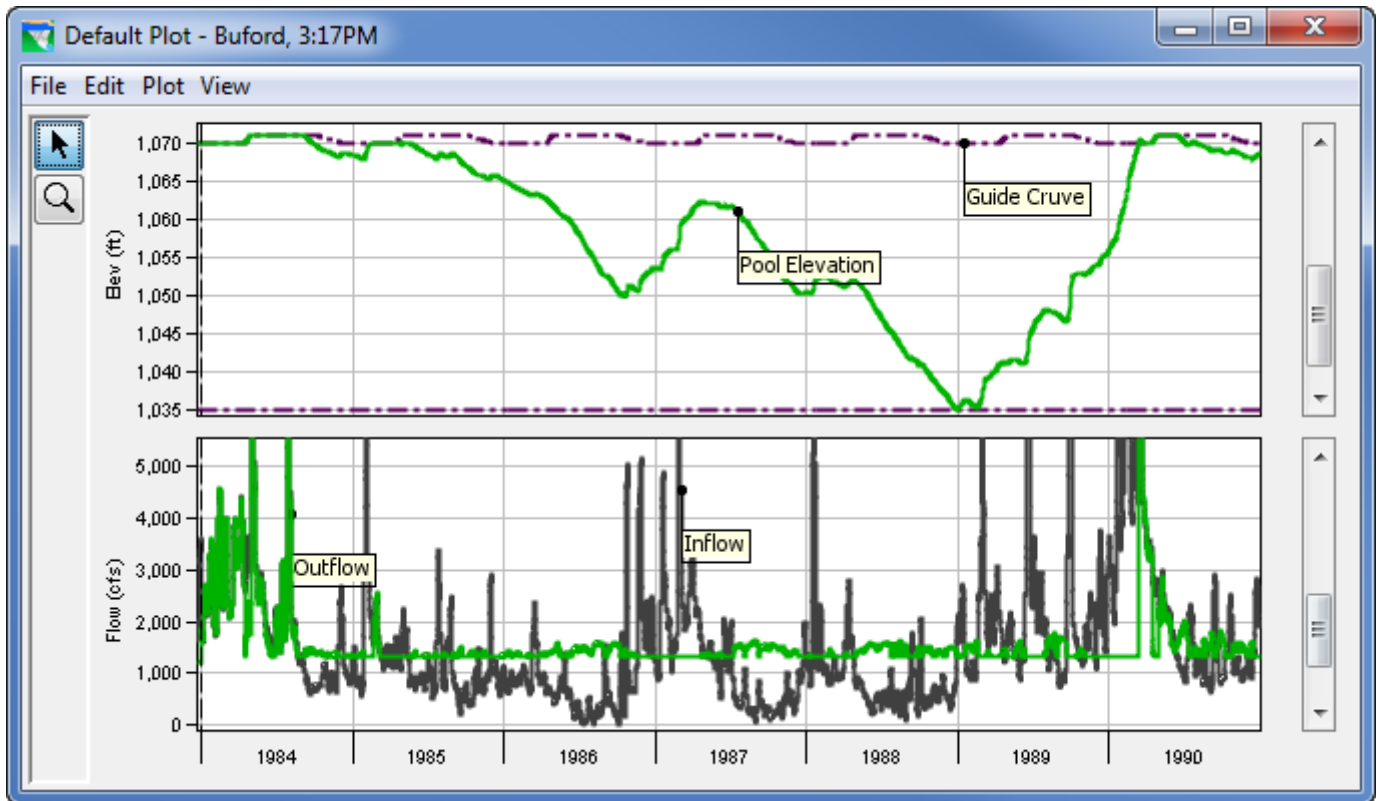


Figure B-50. Buford Critical Yield Result, Method B (With Diversions, Glades Diverted)

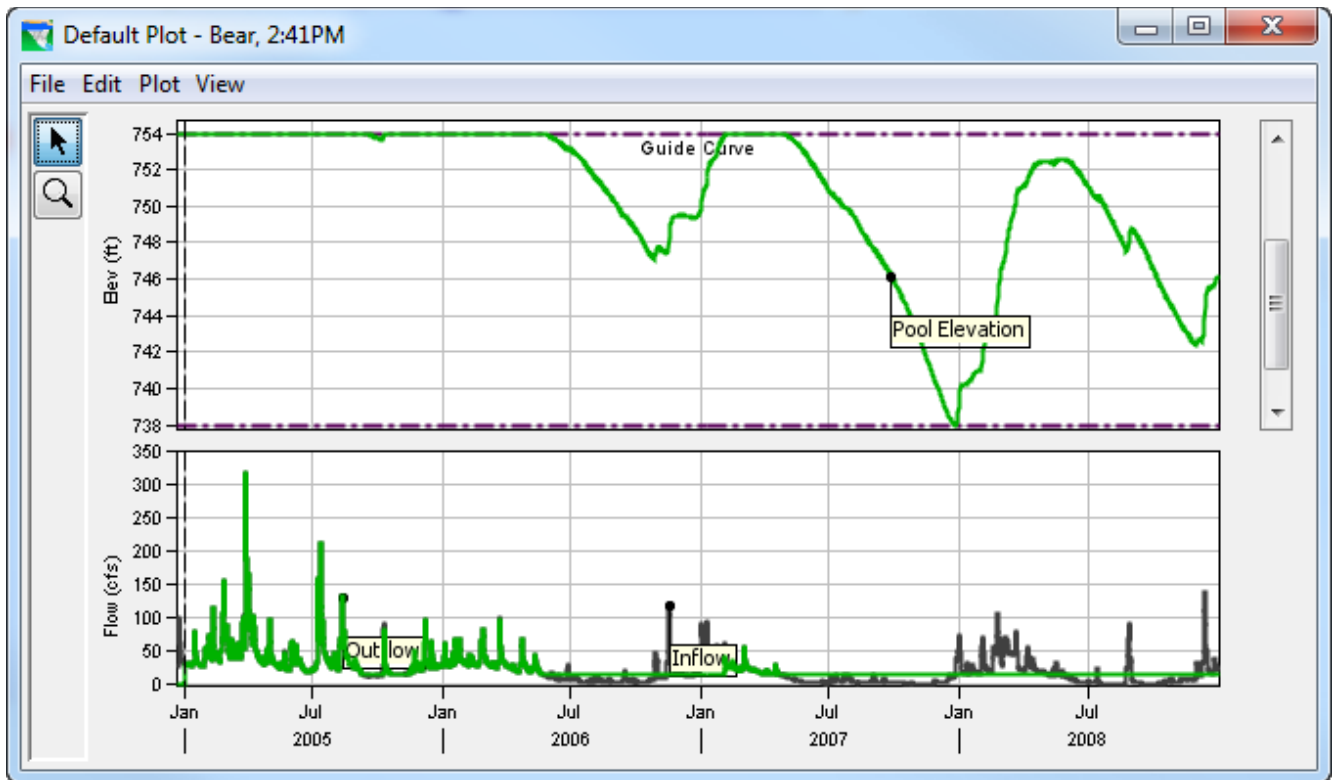


Figure B-51. Bear Creek Critical Yield Result, Method B (With Diversions, Glades Diverted)

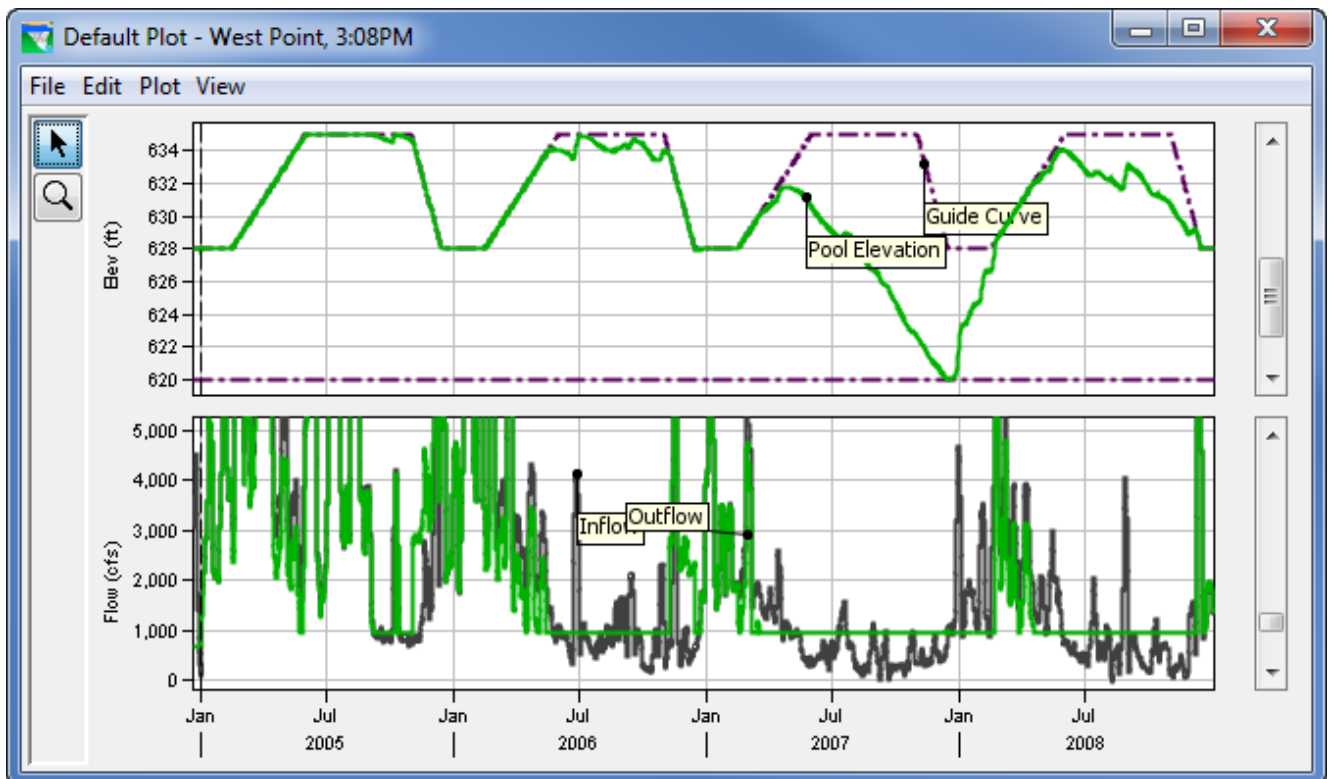


Figure B-52. West Point Critical Yield, Method B (w/Div, Glades & Bear Creek Diverted Out)

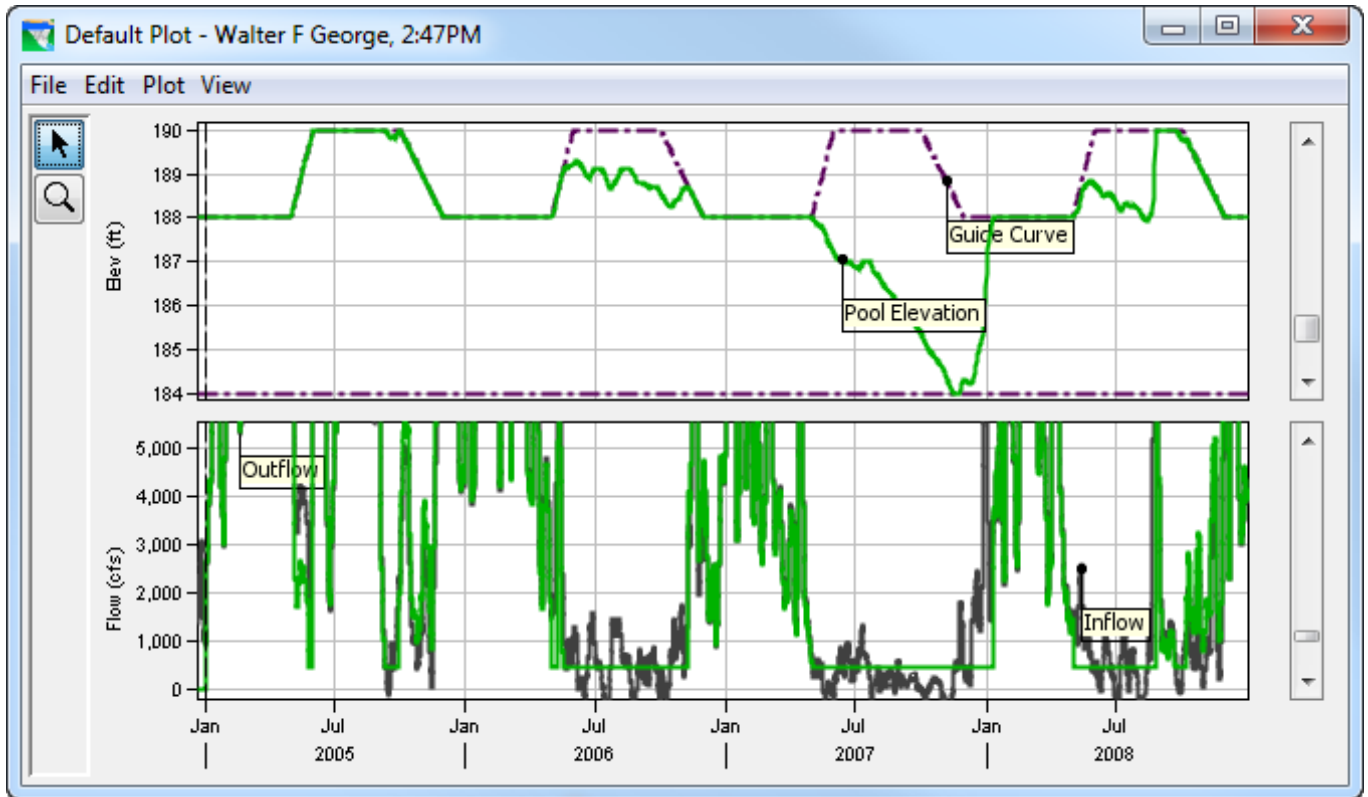


Figure B-53. WFG Critical Yield Result, Method B (w/Div, Glades & Bear Creek Diverted Out)

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

Project	Drought Period					Critical Period
	1940	1950	1980	2000	2007	
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

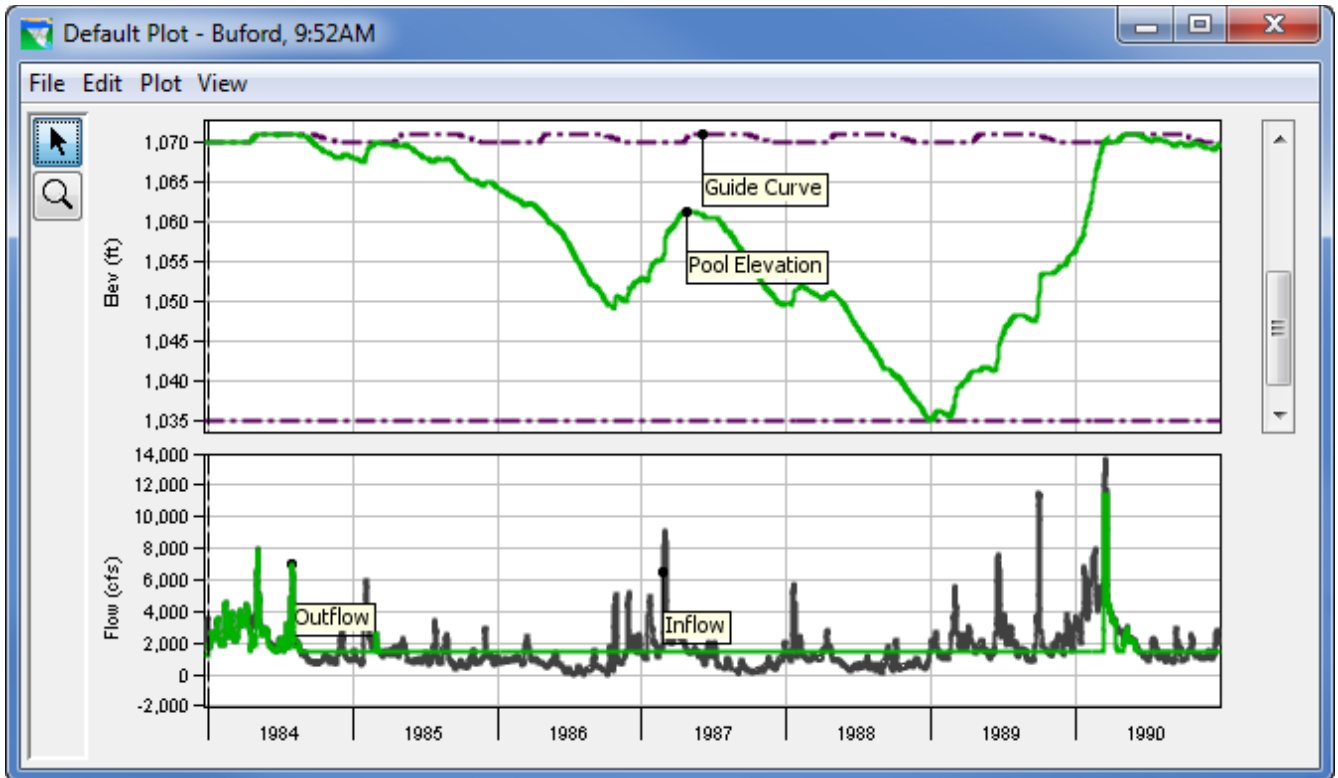


Figure B-54. Buford Critical Yield Result, Method B (w/Div, Glades Flow Thru)

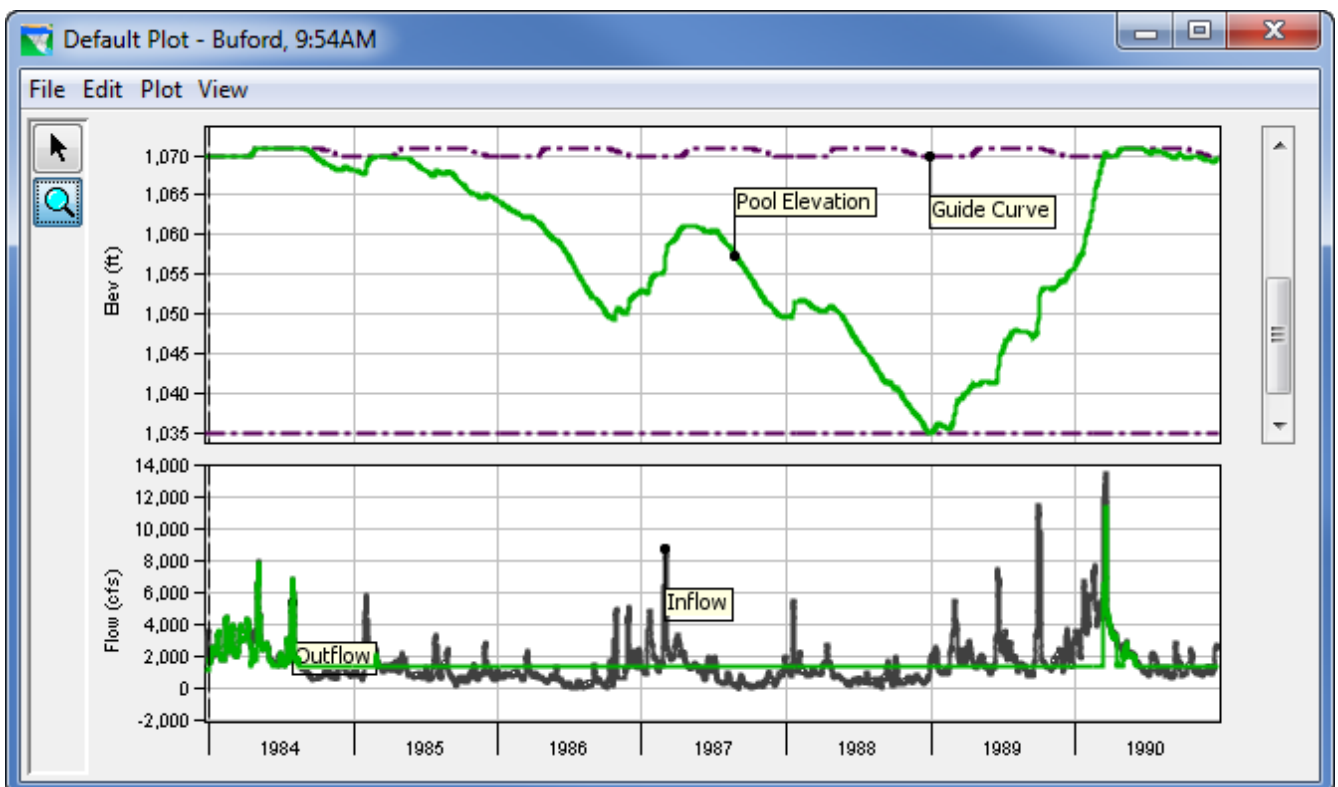


Figure B-55. Buford Critical Yield Result, Method B (w/Div, Glades Diverting Out)

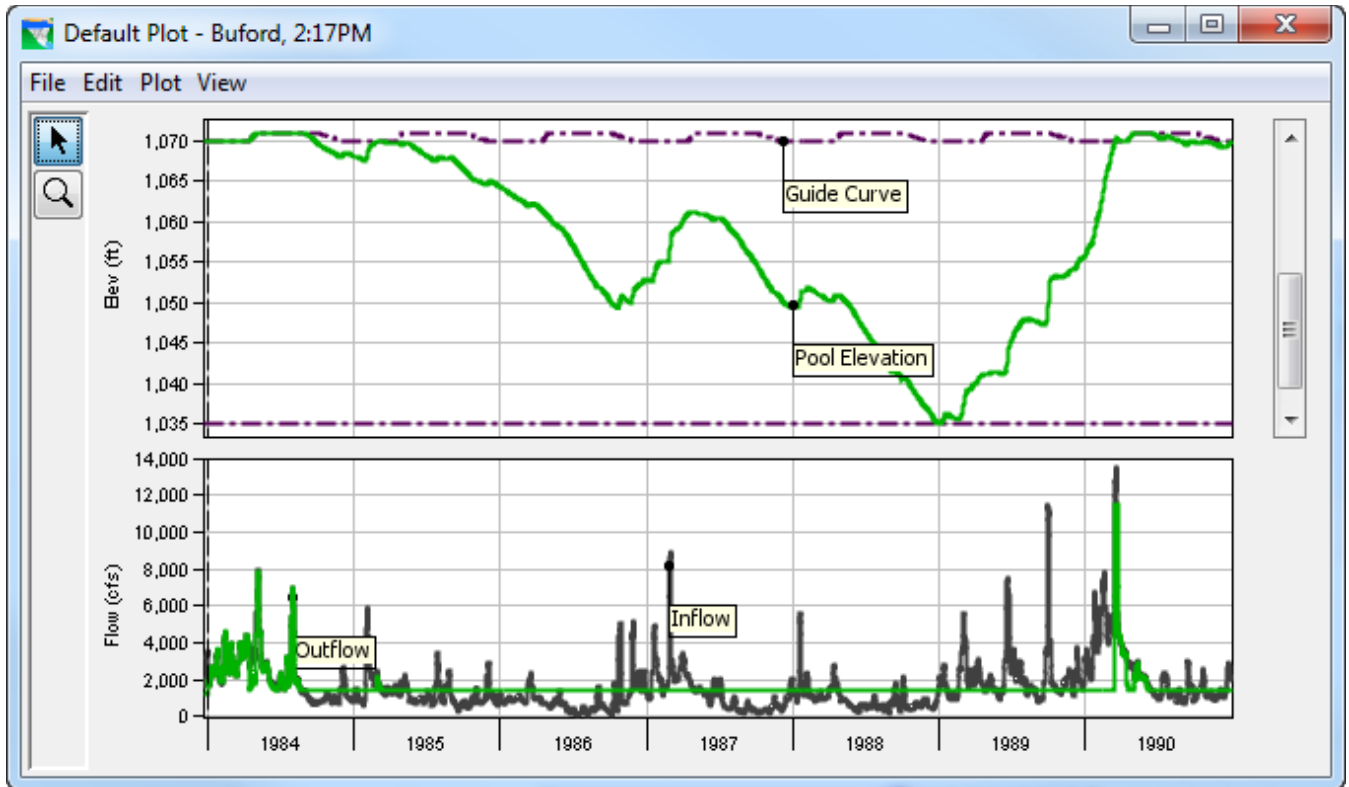


Figure B-56. Buford Critical Yield Result, Method B (w/Div, Glades Diverting Back)

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

Project	Drought Period					Critical Period
	1940	1950	1980	2000	2007	
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

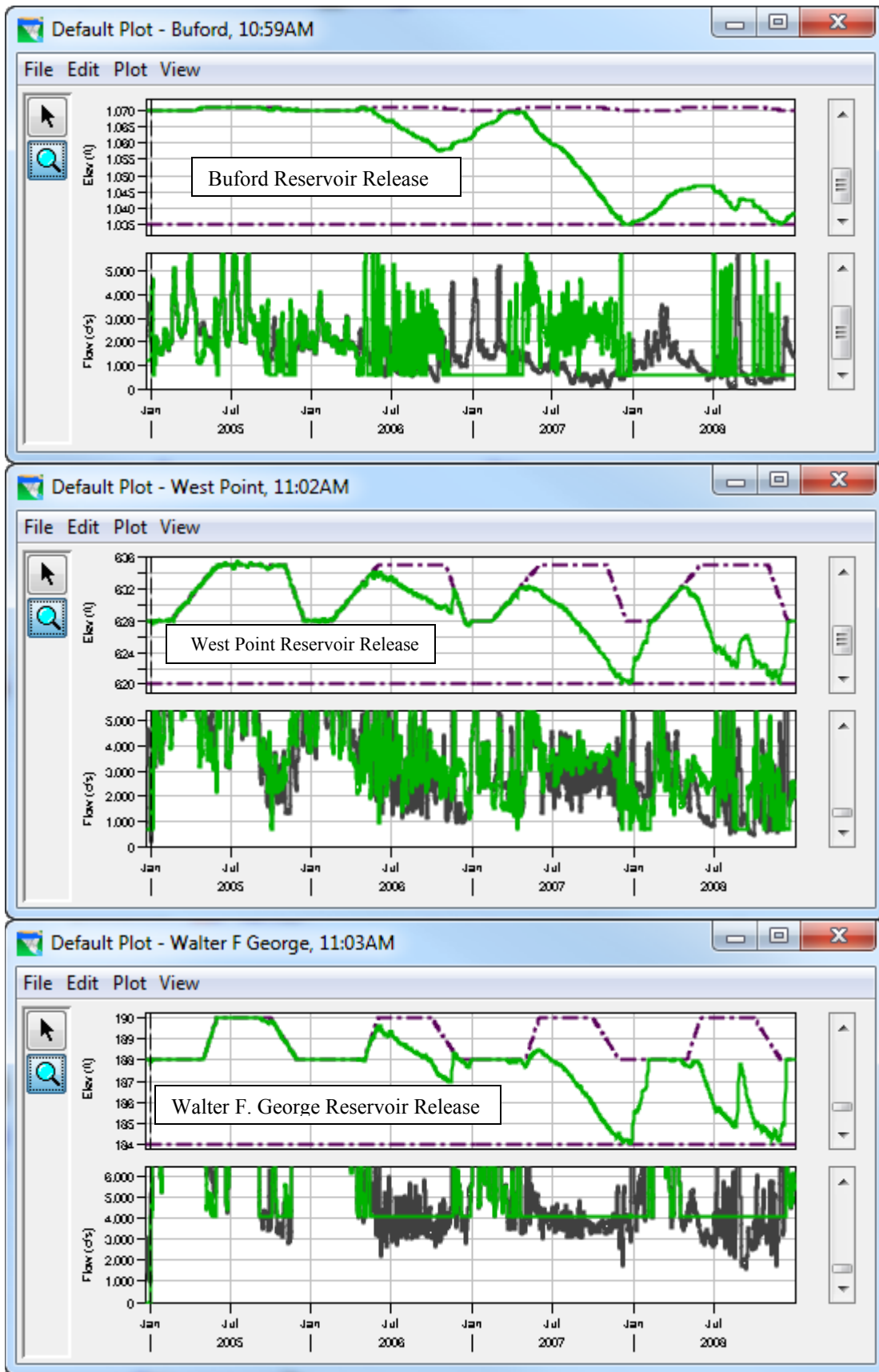


Figure B-57. System Critical Yield Result, Method C (No Diversions)

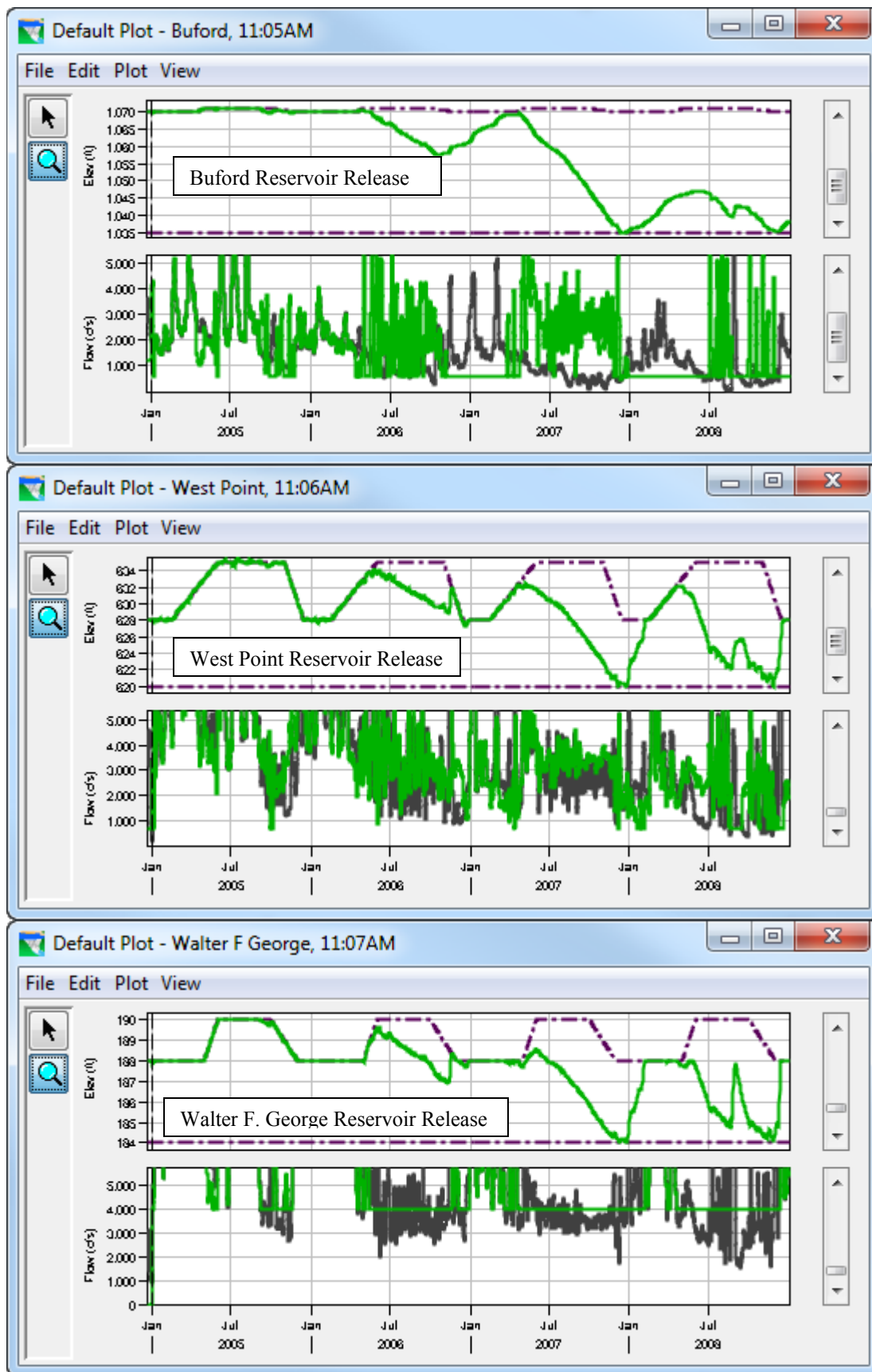


Figure B-58. System Critical Yield Result, Method C (With Diversions)

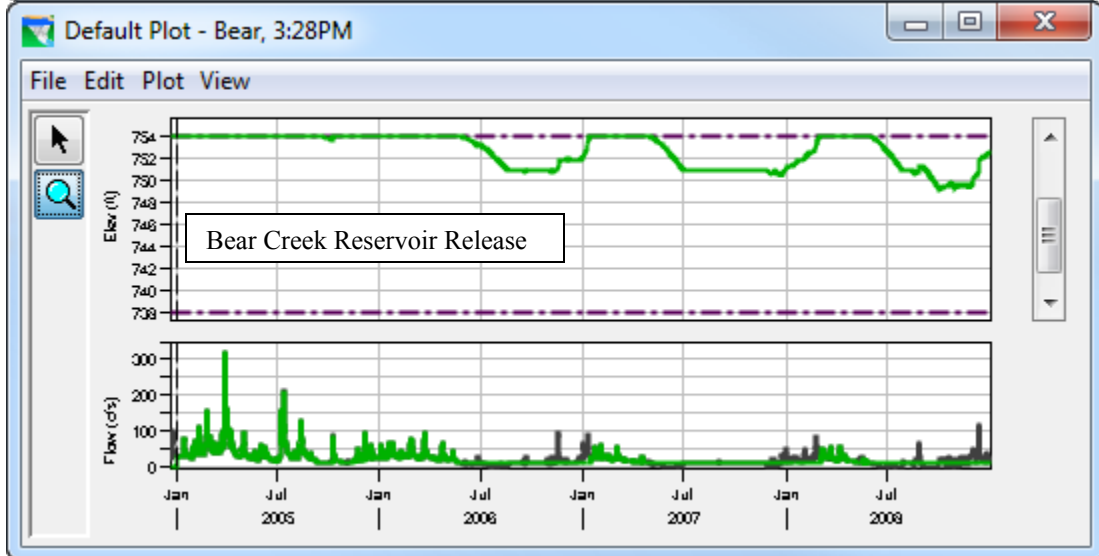
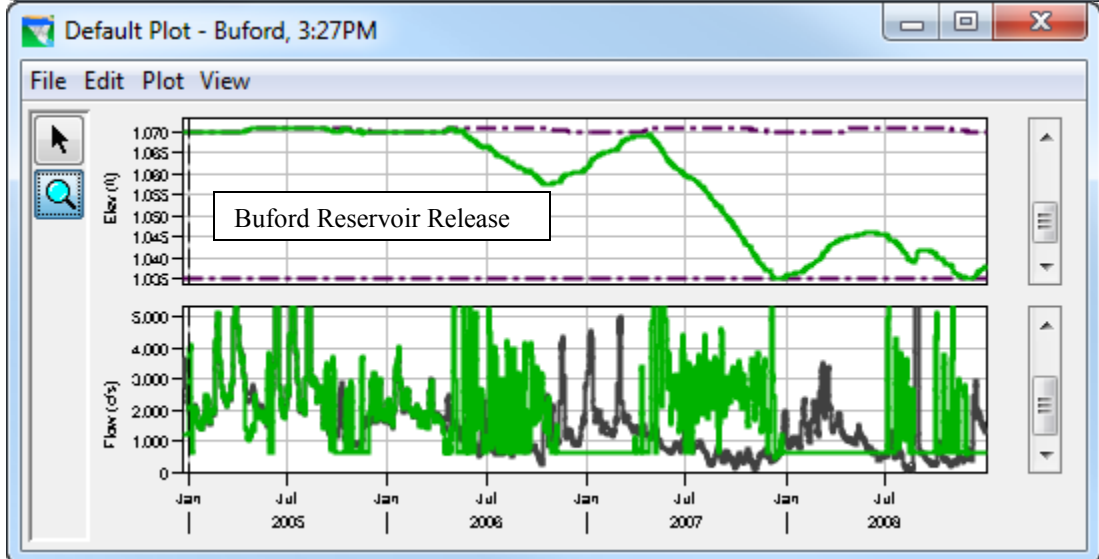
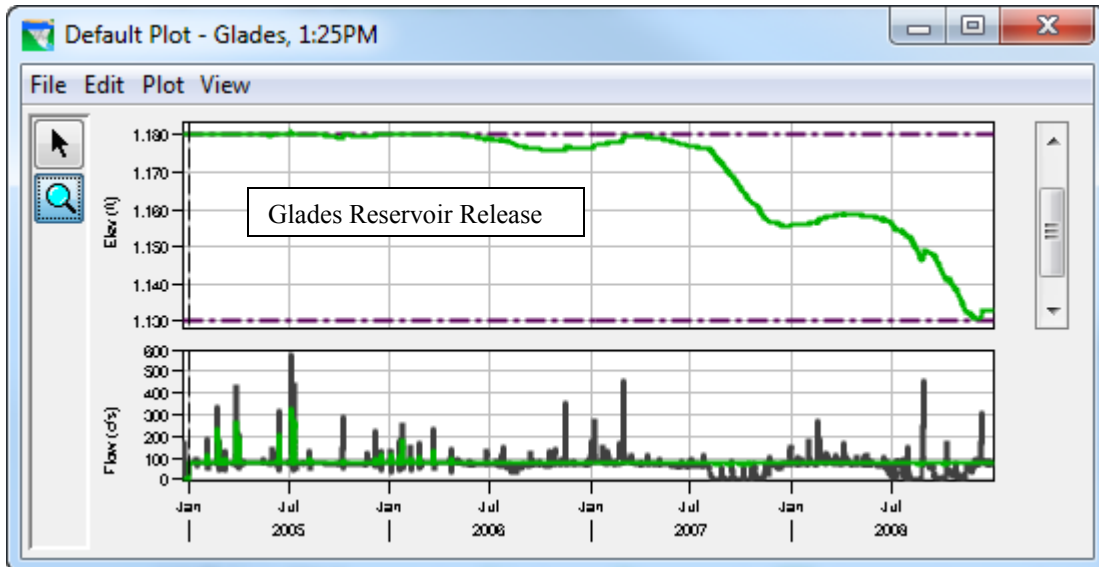




Figure B-59. System Critical Yield Result, Method C (With Diversions, Glades and Bear Yield Diverted Out)

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, Volume 1	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, 87 th 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

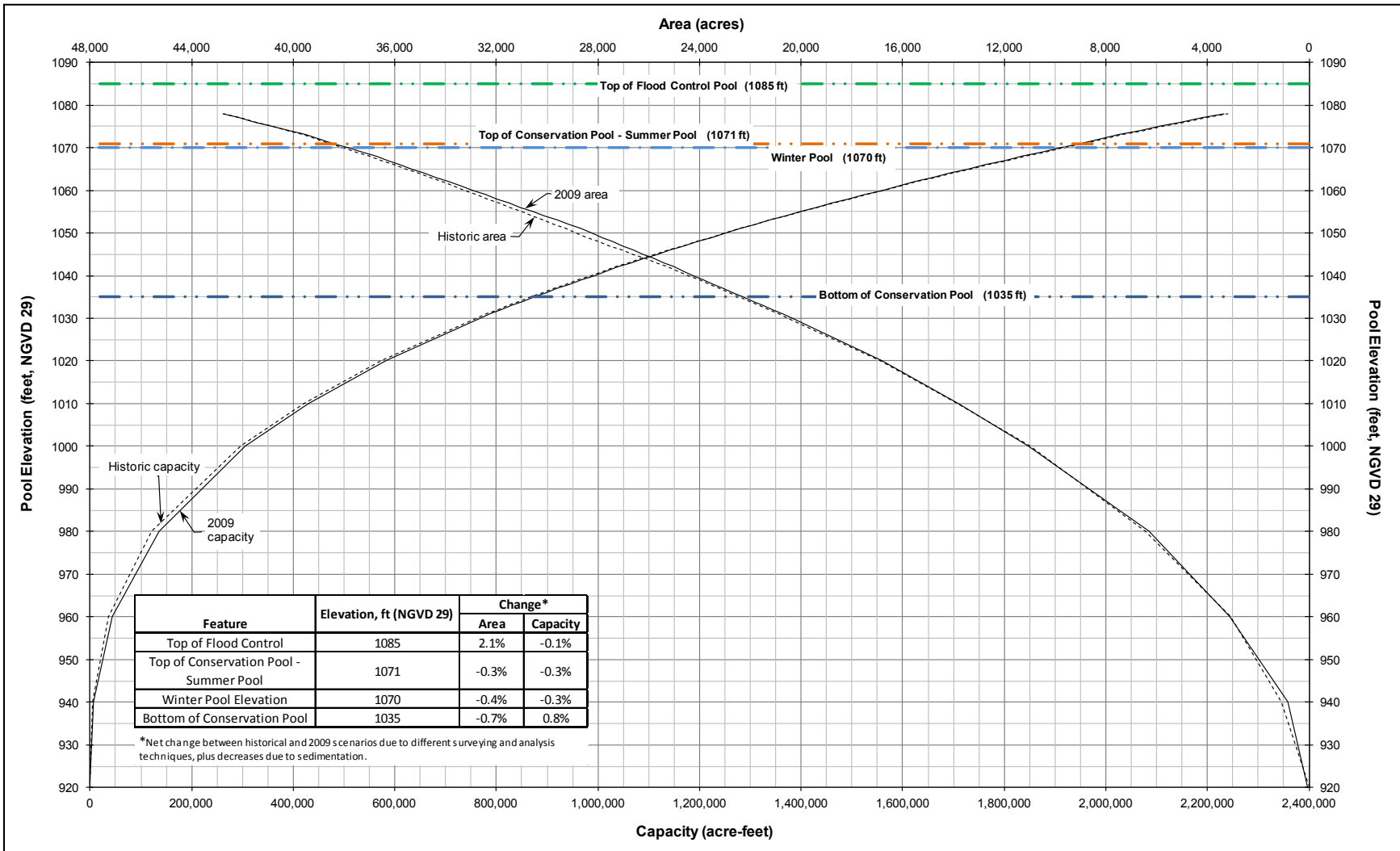


Figure E-1 Buford Dam (Lake Lanier) Storage-Area Comparison, Historic vs 2009

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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

1 1972. Wells installed before July 1, 1988, were grandfathered into the permitting program. Once issued, a
2 permit cannot be revoked and does not expire, but it can be suspended or modified if the water withdrawn
3 causes adverse effects on nearby water users or limits their use.

4 From 1999 to 2006 the Georgia EPD had a moratorium on farm-permit issuance in the lower Flint River
5 Basin. Farm-use permits are issued for irrigation of general farming, aquaculture, pasture, turf production,
6 orchards, nurseries, and water supply for farm animals; over 75 percent of the farm-use permits are for
7 crop irrigation. As of 2006, nearly 50 percent of the irrigated cropland in the Flint River Basin was in
8 cotton, and an additional 25 percent was in peanuts. Most wells for livestock and aquaculture irrigation
9 use less than 100,000 gal/d and are not permitted (GADNR 2006).

10 During the moratorium, the Georgia EPD evaluated the Lower Flint Basin to determine how best to issue
11 new agricultural water withdrawal permits to prevent overconsumption of groundwater. New permits
12 require accurate latitude and longitude coordinates of proposed well and surface-water pump locations
13 and depth of withdrawal, which the Georgia EPD uses to calculate the radius of influence and determine
14 whether the proposed well will impact adjacent users or nearby springs and streams. If an impact would
15 occur, the Georgia EPD modifies the permit as needed. The Georgia EPD no longer issues permits for
16 wells in the Floridan aquifer that are within 0.25 mile of another well, unless it is shown through a
17 hydrogeologic evaluation that the well will not cause or contribute to excessive drawdown of the
18 neighboring well. Also, the Georgia EPD now conducts random site inspections to ensure that permittees
19 are following permit and conservation guidelines. If a violation is found, the permittee has one growing
20 season to correct it (GADNR 2006).

21 More detailed information on the water withdrawal permitting program can be found at
22 <http://epd.georgia.gov/water-withdrawal-permitting>.

23 **1.2 State Drought Management Plan**

24 The 1998–2002 drought raised awareness in Georgia regarding drought impacts and interest in drought
25 planning and management. The first *Georgia Drought Management Plan* was adopted by the Georgia
26 DNR Board in March 2003 (GAEPD 2003). The plan was developed using a collaborative approach
27 involving stakeholders with interest and/or expertise in water-related matters. These stakeholders
28 represented a geographical and political cross section of the state, as well as a cross section of business,
29 industry, environmental, and water management interests. The Georgia General Assembly and the Board
30 of Natural Resources have assigned the Director of the Georgia EPD principal responsibilities for
31 implementing the drought management plan. Numerous agencies and organizations are tasked in this plan
32 with some level of water resource or water-related management responsibilities. The Georgia EPD and
33 those agencies and organizations must coordinate closely and share information about their drought or
34 water conservation concerns and solutions.

35 The plan contains an array of pre-drought strategies, primarily oriented around water conservation. They
36 are generally longer-term actions, implemented before a drought for the purpose of preparedness,
37 mitigation, monitoring, and conservation. For example, during non-drought periods, municipal outdoor
38 water use (other than specifically exempted activities) may occur only as follows: For odd-numbered
39 addresses, outdoor water use is allowed on Tuesdays, Thursdays, and Sundays; for even-numbered
40 addresses, outdoor water use is allowed on Mondays, Wednesdays, and Saturdays. As water conservation
41 plans are developed by other agencies, regional development centers (RDCs), local governments, and
42 water supply providers, they are to reflect the pre-drought strategies of the state plan (GAEPD 2003).

1 The State Climatologist's office and the Georgia EPD routinely monitor and evaluate streamflows, lake
 2 levels, precipitation, groundwater levels, and other climatic indicators that are supplied by several
 3 cooperating entities, principally the USACE (US Army Corps of Engineers), USGS (US Geological
 4 Survey), and the National Drought Mitigation Center. These drought indicators reflect the health of the
 5 hydrologic system. Georgia is divided into nine climate divisions (regions), and each division has several
 6 indicators.

7 When the indicators in one or more of the nine climate divisions dictate the possible need for a drought
 8 response declaration, the EPD Director consults with a designated Drought Response Committee (with
 9 state, federal, and stakeholder representatives) to determine the potential severity of the drought
 10 condition(s) and the expected impacts. The Director, in consultation with the Committee, then determines
 11 the appropriate level of response. Response guidance for each level of drought severity is provided by the
 12 plan, but particular drought conditions might require greater or lesser responses than those specified in the
 13 plan (GAEPD 2003).

14 During a declared drought, the EPD Director and, as appropriate, other members of the Drought
 15 Committee notify the local RDCs, local governments, and water supply providers as to the appropriate
 16 action to be taken. Press releases are prepared to explain the situation and state response requirements.
 17 The State Climatologist and the Georgia EPD continue to monitor the drought indicators for changing
 18 conditions, and they act in response to those changing conditions. As drought conditions improve, a
 19 conservative approach is taken before the Director acts to decrease the drought level (GAEPD 2003).

20 As an example of drought response actions that may be triggered under the plan, Georgia Rules and
 21 Regulations, Chapter 391-3-30-.04 (GAEPD 2004), specifically define those response actions required for
 22 outdoor water use under drought response levels of increasing severity:

23 **391-3-30-.04 Outdoor Water Use Schedule during Declared Drought Response Levels**

- 24 (1) The director of the EPD is authorized to make drought declarations.
 25 (2) During declared drought conditions, outdoor water use, other than activities exempted in
 26 391-3-30-.05, shall occur only during scheduled hours on the scheduled days.
 27 (3) *Declared Drought Response Level One* – Outdoor water use may occur on scheduled days within
 28 the hours of 12:00 midnight to 10:00 a.m. and 4:00 p.m. to 12:00 midnight.
 29 (a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays, and Sundays.
 30 (b) Scheduled days for even-numbered addresses are Mondays, Wednesdays, and Saturdays.
 31 (c) Use of hydrants for any purpose other than firefighting, public health, safety, or flushing is
 32 prohibited.
 33 (4) *Declared Drought Response Level Two* – Outdoor water use may occur on scheduled days within
 34 the hours of 12:00 midnight to 10:00 a.m.
 35 (a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.
 36 (b) Scheduled days for even-numbered addresses and golf course fairways are Mondays,
 37 Wednesdays and Saturdays.
 38 (c) The following uses are prohibited:
 39 1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.
 40 2) Washing hard surfaces, such as streets, gutters, sidewalks and driveways except when
 41 necessary for public health and safety.
 42 (5) *Declared Drought Response Level Three* – Outdoor water use may occur on the scheduled day
 43 within the hours of 12:00 midnight to 10:00 a.m.
 44 (a) The scheduled day for odd-numbered addresses is Sunday.
 45 (b) The scheduled day for even-numbered addresses and golf course fairways is Saturday.

1 (c) The following uses are prohibited:

2 1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.

3 2) Washing hard surfaces, such as streets, gutters, sidewalks, driveways, except when
4 necessary for public health and safety.

5 3) Filling installed swimming pools except when necessary for health care or structural
6 integrity.

7 4) Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, golf carts.

8 5) Washing buildings or structures except for immediate fire protection.

9 6) Non-commercial fund-raisers, such as car washes.

10 7) Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls
11 except when necessary to support aquatic life.

12 (6) *Declared Drought Response Level Four* – No outdoor water use is allowed, other than for
13 activities exempted in 391-3-30-.05, or as the EPD Director may order.

14 Exemptions from the outdoor water restrictions in Chapter 391-3-30-.05 include capture and reuse of
15 cooling system condensate or storm water, reuse of gray water, landscape water uses with reclaimed
16 wastewater, irrigation of personal gardens, specific and limited exceptions for newly installed landscapes,
17 specific and limited exemptions for golf courses water use, and specific and limited exemptions for
18 businesses whose operations are dependent on outdoor water use (GAEPD 2004).

19 Most of the measures in the plan are short-term actions to reduce water demand during a drought, rather
20 than long-term demand management. The plan does not encompass measures to control long-term water
21 demand related to population growth, nor does it contain significant measures to manage the demand of
22 the industrial and agricultural sectors. This is a limitation typical of state drought plans. The state is
23 addressing these longer-term issues through the development of the statewide water plan and water
24 conservation implementation plan (CRS 2008), summarized in Sections 1.4 and 1.6.

25 The 2006–2008 period of drought provided the first serious test of the plan. Level 1 drought was declared
26 for entire state in June 2006, with progressively more severe declarations through early 2007, culminating
27 in a Level 4 drought declaration for 61 northern and western counties (primarily along the Chattahoochee
28 River, and some of the Flint River counties) in September 2007, including prohibition on most outdoor
29 residential water use. In October 2007, Governor Perdue went beyond the Drought Management Plan’s
30 Level 4 actions by calling for a 10 percent cut in withdrawals by groundwater and surface water permit
31 holders in 61 counties (CRS 2008).

32 The drought management is available at

33 http://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/drought_mgmtplan_2003.pdf.

34 **1.3 Flint River Basin Regional Water Development and Conservation Plan**

35 The Georgia EPD initiated the Flint River Regional Water Development and Conservation Plan (the plan)
36 in October 1999 in response to growing concern over agricultural irrigation in southwest Georgia.

37 Computer models of stream-aquifer relationships and surface water flows indicated that, under conditions
38 of extreme drought and greatly increased irrigation, the Flint River and some of its tributaries could
39 virtually stop flowing. The plan included a moratorium on the issuance of new farm use permits for the
40 Floridan aquifer in southwest Georgia; however, it also called for extensive scientific study of stream-
41 aquifer relations and agricultural water use, and the creation of an Advisory Committee to assist the
42 Georgia EPD in crafting the plan (McDowell 2005).

1 Development of the plan was precipitated by:

- 2 • Growing recognition that drought-year agricultural irrigation from the Floridan aquifer in
3 southwest Georgia could affect streams hydraulically connected to the aquifer, as documented in
4 a 1996 report issued by USGS. Specifically, groundwater baseflow to the Flint River and several
5 major tributaries could become negative, which, coupled with already low surface water flows,
6 could lead to brief periods of actual drying of some stream segments (Torak and McDowell
7 1996). This would threaten the endangered species of Unionid mussels native to the lower Flint
8 River Basin. It could also lead to contamination of the Floridan aquifer (McDowell 2005).
- 9 • A 4 yr period of drought began in 1998. This led to an increase in the number of farmers seeking
10 farm-use withdrawal permits in southwest Georgia. By spring 1999, hundreds of permit
11 applications had been received, prompting the Georgia EPD Director to place a moratorium on
12 new Floridan aquifer permits in the lower Flint River Basin (McDowell 2005).

13 In addition to the moratorium, a series of studies of agricultural practices in the region, metering of
14 irrigation systems, additional hydrogeologic investigations, and other technical studies were pursued,
15 along with significant stakeholder involvement (McDowell 2005).

16 The planning process was completed in 2006. The goals of the Plan, as defined by statute, are to promote
17 conservation and reuse of water, guard against a shortage of water, promote the efficient use of water
18 resources, and manage the water resources of the Flint River Basin such that they are sustainable and
19 consistent with the public welfare. The moratorium on new farm-use permits was lifted, but applications
20 are closely evaluated to meet the requirements of the plan. Permitting decisions are based on the
21 requested amount of water, the connections between groundwater and surface water as determined by
22 computer models, the impact of water withdrawals on streamflows, and the presence of endangered or
23 threatened species (GAEPD 2006).

24 The Plan is available at <http://www1.gadnr.org/frbp/index.html>.

25 **1.4 Georgia Statewide Water Management Plan**

26 The 2004 Comprehensive Statewide Water Management Planning Act authorized the development of the
27 Statewide Water Management Plan (SWP). The act established the following goal: “Georgia manages
28 water resources in a sustainable manner to support the state’s economy, to protect public health and
29 natural systems, and to enhance the quality of life for all citizens.” The Georgia EPD was charged with
30 developing a draft of the plan, with oversight by the Water Council. Created by the act, the Water Council
31 is a coordinating committee composed of the heads of eight state agencies with water-related
32 responsibilities, four legislators, and two citizen members (GAEPD 2008).

33 Between January 2006 and July 2007, EPD used an intensive public involvement process to develop the
34 draft plan. As required by the act, the draft plan was submitted to the Water Council by July 1, 2008.
35 Drawing on additional public review and comment, the Water Council revised the plan and submitted it to
36 the Georgia General Assembly in January 2009. By the end of February 2009, the plan had been adopted
37 by the General Assembly and signed by the governor (Cowie and Davis 2009).

38 The SWP has three major components designed to address the goal for water management in Georgia:
39 (1) Resource Assessments and Forecasting of Needs, (2) Tool Box of Water Management Practices, and
40 (3) Framework for Regional Water Planning.

41 The SWP makes provisions to conduct resource assessments and generate long-range forecasts. The
42 resource assessments focus on water quantity and water quality. The water quantity resource assessment

1 addresses the amount of water that is available to withdraw for beneficial use, while still supporting the
2 ability of downstream users, or users from the same aquifer, to benefit from that water resource. The
3 water quality resource assessment addresses, from a watershed perspective, the wastewater treatment
4 levels that are required to protect water quality. In addition, statewide and regional population and
5 economic forecasts are translated in a consistent manner into water and wastewater demand forecasts over
6 a 50 yr planning horizon (Cowie and Davis 2009).

7 The SWP explicitly recognizes that regional variation means that different sets of water management
8 practices will be better suited to different parts of the state. The *toolbox* of water management practices
9 includes demand management practices; water return practices such as onsite sewage management (septic
10 systems) and centralized wastewater treatment; and water supply management practices such as surface
11 water storage, inter- and intra-basin transfers, and aquifer storage and recovery. Water conservation is
12 highlighted as a priority practice for use across the state by all water use sectors. Water quality
13 management practices, including stormwater and nonpoint source pollution management, are also part of
14 the toolbox (Cowie and Davis 2009).

15 The SWP provides a framework for regional water planning. Through regional water planning, water
16 management practices will be selected and defined for implementation. Ten regional water planning
17 councils have been formed to prepare recommended Water Development and Conservation Plans
18 (WDCPs). Each council consists of 25 members that represent the water users and the water-related
19 interests in each region. Council members are appointed by the governor, lieutenant governor, and
20 speaker of the house.

21 WDCPs will characterize the water needs for each region as those needs relate to the needs of adjacent
22 regions and the preferred water management practices to use in each region to close any gaps between
23 water capacities and water needs. The councils will use the resource assessments and forecasts to develop
24 the recommended WDCPs. Recommended plans will be submitted to the Georgia EPD for review,
25 revision if needed, and ultimately adoption by the Georgia EPD Director. Under the 2004 act, water
26 withdrawal permits and state loans for infrastructure projects must be consistent with the regional plans
27 (Cowie and Davis 2009).

28 Resource assessments and the forecasts of water and wastewater needs were developed in 2010.
29 Preparation of the WDCPs was fully underway in 2010. The first set of WDCPs was adopted in 2011.
30 The 2004 act calls for review of the SWP every 3 yr to determine whether revisions are necessary. After
31 the Georgia EPD adopts the first set of WDCPs, those plans will also be reviewed and revised on a 3 to
32 5 yr cycle (Cowie and Davis 2009).

33 The state-wide water plan and pertinent documents are available at <http://www.georgiawaterplanning.org>.

34 **1.5 Georgia Environmental Finance Authority Reservoir Study (2008)**

35 In response to one of its mandates under the Georgia Water Supply Act of 2008 (O.C.G.A. 12-5-470), the
36 Georgia Environmental Facilities Authority (GEFA) conducted an inventory and survey of feasible sites
37 for multi-jurisdictional drinking water supply reservoirs in Georgia. The effort also considered reservoirs
38 under development or specifically proposed, existing reservoirs with potential expansion volumes, and
39 possible reservoir locations extracted from prior studies. The report was intended to provide information
40 and preliminary analysis that can support decisions by local governments and Regional Planning Councils
41 on how best to augment local water supply. The report is summarized in the following paragraphs (GEFA
42 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

1 Sixteen additional potential water supply reservoir sites in the Georgia portion of the ACF Basin were
 2 identified and inventoried from available prior studies and published reports (Table 3). Georgia has
 3 placed a high priority on progress toward increasing water supply availability, as evidenced by the
 4 significant investment that the state has made and will continue to make in the statewide water planning
 5 process. The SWP and the Regional Water Plans will make more comprehensive data and analysis tools
 6 available to guide future water supply planning.

7 **Table 3.**
 8 **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

9
 10 The full GEFA study report is available at
 11 [https://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/site_page/GEFA-](https://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/site_page/GEFA-MACTEC%20Inventory%20and%20Survey%20of%20Feasible%20Reservoir%20Sites.pdf)
 12 [MACTEC%20Inventory%20and%20Survey%20of%20Feasible%20Reservoir%20Sites.pdf](https://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/site_page/GEFA-MACTEC%20Inventory%20and%20Survey%20of%20Feasible%20Reservoir%20Sites.pdf).

13 1.6 Georgia Water Conservation Implementation Plan

14 In May 2009, the Georgia EPD published a comprehensive Water Conservation Implementation Plan
 15 (WCIP), designed to create a culture of conservation in the state and to guide Georgians toward more
 16 efficient use of the state's finite water resources (GADNR 2009a). The WCIP is a product of the ongoing
 17 Georgia SWP process. The plan provides a multi-pronged strategy to achieve more efficient and
 18 sustainable water use through conservation (defined as beneficial reduction in water use, water waste, and
 19 water loss) and measures to promote more efficient use of water (maximizing benefit from each gallon
 20 used). The plan was developed in conjunction with representatives of state agencies, local governments,
 21 and a wide range of stakeholder interests.

22 The WCIP provides specific goals and benchmarks for Georgia's seven major water use sectors.—
 23 agricultural irrigation; power generation, golf courses, industrial and commercial, landscapes, domestic
 24 and nonindustrial public uses, and state agencies. For each sector, the WCIP details water conservation
 25 goals, benchmarks, best practices, and implementation actions designed to reduce water waste, water loss,
 26 and, where necessary, water use.

1 The WCIP is used to guide decisions related to water use and water management by:

- 2 • Educating water users about water conservation practices and the goals they can accomplish
- 3 • Informing regional water plan preparation, which will be overseen by regional water planning
- 4 councils
- 5 • Helping water use sectors collectively improve water use efficiency
- 6 • Informing Georgia DNR rule-making regarding water conservation requirements in permitting.

7 The WCIP program document is available at <http://www.conservewatergeorgia.net/documents/wcip.html>.

8 Conserve Water Georgia (<http://www.conservewatergeorgia.net/index.html>) is a water conservation
9 clearinghouse of the Georgia EPD (GADNR 2009b). The focus of the clearinghouse is public
10 information, education, and awareness. The site provides tips and tools for individuals, teachers and
11 students, business and industry, and communities and local governments on conservation and water
12 efficiency strategies.

13 Conserve Water Georgia promotes *waterSmart*, an education program designed to give Georgians
14 information they need to successfully conserve water. The Cobb County-Marietta Water Authority
15 developed *waterSmart* in 2000 for residents in its service area (<http://www.watersmart.net>), and the
16 Georgia EPD began using the *waterSmart* brand in communications and education activities in 2006 to
17 help residents statewide understand how to maintain their landscapes while using less water. The state
18 *waterSmart* program was piloted in six communities (Albany, Augusta, Cobb County, Columbus, Dalton,
19 and Macon) in 2007, and it went statewide through a partnership with University of Georgia Cooperative
20 Extension in 2008.

21 Conserve Water Georgia promotes participation in USEPA's *WaterSense* program
22 (<http://www.epa.gov/watersense>). *Watersense* can help consumers identify products and services that use
23 less water while performing as well as or better than conventional models, thus saving natural resources,
24 reducing water consumption, and saving money. *WaterSense* makes it easy to find and select water-
25 efficient products with a label backed by independent testing and certification. *WaterSense* also
26 recognizes some professional service programs that meet its specifications by incorporating a strong
27 water efficiency component.

28 **1.7 Governor's Water Contingency Planning Task Force (2009)**

29 In response to the July 17, 2009, Federal District Court ruling that water supply was not an authorized
30 purpose of Buford Dam/Lake Sidney Lanier, which would severely limit the ability to continue water
31 supply withdrawals from the lake or conduct dam operations to meet downstream needs for metro
32 Atlanta, the Governor of Georgia outlined a four-part strategy. The strategy consisted of (1) appealing the
33 ruling in court, (2) negotiating a mutually agreeable water allocation formula with Alabama and Florida,
34 (3) pursuing congressional reauthorization of Lake Lanier for water supply, and (4) developing a
35 contingency plan, to be implemented if the District Court ruling were to take effect. The Water
36 Contingency Planning Task Force was created to evaluate the various options for a contingency plan and
37 make recommendations to the governor. The Task Force included several dozen leaders from business,
38 government, and environmental organizations. The following paragraphs summarize the report of the task
39 force to the governor (Office of the Governor of Georgia 2009).

40 Implementing the District Court ruling would create a water supply shortfall for areas in the Metropolitan
41 North Georgia Water Planning District in July 2012. The Task Force used a shortfall estimate of 280 mgd
42 for planning purposes. Assuming that demand continued to grow as outlined in the Metro Water Plan, the

1 corresponding water shortfalls in 2015 and 2020 were estimated to be approximately 310 mgd and
2 350 mgd, respectively.

3 The Task Force had two key objectives: (1) to develop a fact base to educate business and community
4 leaders on Georgia's water situation and the implications of the District Court ruling and (2) to define a
5 time-driven action plan that prioritized specific options and recommendations for conservation, supply
6 enhancement, and water policy to address the potential shortfall.

7 Upon completing its evaluation, the Task Force concluded that Lake Lanier would be the best and most
8 cost-effective water supply source for the Metro Atlanta region. The Task Force further concluded that
9 the recommended contingency options, if required, would impose significant incremental economic costs
10 and environmental impact on the region.

11 The Task Force did not foresee the ability of the region to meet the potential water shortfall in 2012, when
12 the District Court ruling would take effect, even with extremely aggressive mandated conservation.
13 Within this time frame, no new supply options could offer significant yield. By 2015, there is a potential
14 contingency solution, consisting primarily of an indirect potable reuse project, along with a set of
15 conservation measures and isolated groundwater options. The 2015 solution would, however, require
16 significant up-front capital of approximately \$3 billion and would supply water at an average incremental
17 unit cost of \$890 per million gallons (MG). By 2020, a broader set of more cost-effective options exists
18 because reservoirs and transfers could be implemented. In that regard, the Task Force recommended a
19 2020 contingency solution that considers cost efficiency, environmental impact, and implementation
20 feasibility criteria. This solution would include conservation measures and groundwater options that could
21 be available for the 2015 solution, but it would replace the relatively expensive indirect reuse project with
22 more cost-effective reservoir expansions (Tusahaw Creek in the Ocmulgee River basin and Dog River in
23 the Chattahoochee River basin) and a new reservoir (Richland Creek in the Etowah River basin). The
24 2020 contingency solution would require a lower up-front capital requirement of approximately
25 \$1.7 billion and would have an incremental unit cost of \$460/MG, which is nearly half the 2015 solution
26 cost.

27 Although the supply options for 2015 and 2020 are identified as contingencies, the Task Force
28 recommended that enhanced conservation, implemented through incentive-based programs, should be
29 pursued regardless of the outcome of Lake Lanier reauthorization. This program of enhanced
30 conservation was the basis for a set of Task Force recommendations on options to implement
31 immediately, along with a supporting set of policy considerations, which are detailed in the Task Force
32 report. There are three broad areas of additional conservation improvements that build on Metro Atlanta's
33 conservation progress to date, and they are reflected in these recommended policies:

- 34 • Institute mandatory data collection and reporting of key metrics to inform future planning efforts.
35 For instance, utilities would have to conduct standardized water loss audits.
- 36 • Adopt higher water efficiency standards and incentive measures to increase conservation
37 effectiveness (e.g., increasing incentives for fixture and soil meter retrofits).
- 38 • Link progress on conservation efforts to funding eligibility, low-interest loan qualifications, and
39 permitting applications to ensure implementation of measures.

40 The Task Force recommended that contingency solutions should be pursued only if they are deemed
41 absolutely essential, on the basis of the outlook of tri-state water negotiations, Lake Lanier reauthorization
42 efforts, and the appeal of the District Court ruling. Per the Task Force, preference should be given to the
43 2020 contingency solution, if possible, and only if this action is required. In conjunction with the 2020
44 contingency solution, the Task Force also identified a set of policies that could support the
45 implementation of mandate-based conservation measures envisioned within that contingency solution,

1 also to be considered only if necessary to the support a contingency solution. The Task Force noted that
2 the ability to implement a 2015 or 2020 solution within its stated time frame would also be contingent on
3 initiating the necessary technical studies and permitting process swiftly, and implementation within such a
4 time frame would not accommodate any unforeseen delays.

5 In June 2011, the 11th Circuit Court of Appeals overturned the 2009 District Court ruling and confirmed
6 that water supply was, in fact, and authorized project purpose of Lake Lanier. Thus, recommendations by
7 the Governor's Task Force did not have to be implemented as an accelerated contingency plan to address
8 severe short term water supply deficits. Nonetheless, much of the information developed by the Task
9 Force has been utilized by state and local interests in subsequent water supply planning and management
10 activities.

11 The full 2009 task force report is available at
12 [https://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/site_page/Water%20Contingency%20P
13 anning%20Task%20Force%20Report.pdf.](https://gefa.georgia.gov/sites/gefa.georgia.gov/files/related_files/site_page/Water%20Contingency%20Planning%20Task%20Force%20Report.pdf)

14 **1.8 Georgia Water Stewardship Act of 2010 (HB-370)**

15 In light of recent severe water resource management challenges in Georgia, (e.g. frequent droughts, rapid
16 growth, and an unfavorable court ruling that could bar most water withdrawals from Lake Lanier) the
17 General Assembly enacted the Georgia Water Stewardship Act in the 2010 legislative session. On the
18 basis of recommendations from the 2009 Governor's Water Contingency Task Force, the legislation
19 initiated a process for developing alternative supply sources while also reaffirming "the imminent need to
20 create a culture of water conservation in Georgia."

21 Key provisions of the Water Stewardship Act include the following:

- 22 • Requirements for state agencies with water-related programs and responsibilities to review
23 policies and programs encouraging water conservation and enhance water supply
- 24 • Mandates for public water systems serving over 3,300 individuals to implement best practices for
25 water efficiency and conservation and to account for and mitigate water loss leaks
- 26 • Revisions to state minimum construction standards for new buildings, including use of high-
27 efficiency plumbing fixtures and sub-metering of multi-unit buildings for water use
- 28 • Modification of state and local authority to impose outdoor watering restrictions
- 29 • Amendments to the permitting system for agricultural water withdrawals
- 30 • Creation of a joint legislative committee on water supply to examine opportunities for enhancing
31 the state's water supply

32 Implementation of these provisions will require significant action by state agencies, local governments,
33 and public water supply utilities over the next several years (UGA 2010).

34 **1.9 Governor's Water Supply Program**

35 In January 2011, Governor Nathan Deal directed GEFA to develop and launch the Governor's Water
36 Supply Program (GWSP) and committed \$300 million to the program over four years. The purpose of the
37 GWSP is to align and mobilize the resources of the state of Georgia to assist local governments with
38 developing new sources of water supply adequate to meet future water demand forecasts. The financial
39 assistance is available in the form of low interest loans through GEFA and state direct investment through
40 the Georgia Department of Community Affairs (DCA).

1 GEFA convened a Water Supply Task Force (WSTF) that provided expert guidance in the program's
2 development and implementation. GEFA worked with DCA and other WSTF members to develop the
3 report provided to the governor in December 2011, which outlined recommendations for the program.
4 GEFA and DCA also held workshops designed to assist communities seeking funding through the
5 program. In addition to water supply projects, GEFA's loan programs can finance a variety of water and
6 wastewater infrastructure, including water conservation projects.

7 Applications for assistance under the GWSP are solicited annually. Through 2013, about \$165 million has
8 been committed to water supply projects, either in low interest loans or state direct investment. State
9 financial assistance under the GWSP can be used for detailed planning and engineering, land acquisition,
10 construction, and related activities associated with water supply projects.

11 More detail on the GWSP is available at the following web site: [https://gefa.georgia.gov/governors-water-](https://gefa.georgia.gov/governors-water-supply-program)
12 [supply-program](https://gefa.georgia.gov/governors-water-supply-program).

13 **1.10 Metropolitan North Georgia Water Planning District**

14 The Metropolitan North Georgia Water Planning District (MNGWPD or "Metro Water District") was
15 created by the Georgia General Assembly in 2001 (O.C.G.A. 12-5-572) to serve as the water planning
16 organization for the greater metropolitan Atlanta area. The MNGWPD's purpose is to establish policy,
17 create plans, and promote intergovernmental coordination of water issues in the District from a regional
18 perspective.

19 The MNGWPD includes 15 counties (Bartow, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas,
20 Fayette, Fulton, Forsyth, Gwinnett, Hall, Henry, Paulding, and Rockdale counties) as well as
21 92 municipalities partially or fully within these counties (Figure 1). The MNGWPD also has seven
22 authorities that provide water, sewer, and/or stormwater services. The MNGWPD's plans and policies
23 work to protect water resources in the Chattahoochee, Coosa, Flint, Ocmulgee, Oconee and Tallapoosa
24 river basins. The area represented by the MNGWPD includes much of the Upper Chattahoochee River
25 watershed. The District covers a total area of 4,800 sq mi, with approximately 4.8 million residents
26 (MNGWPD 2008).

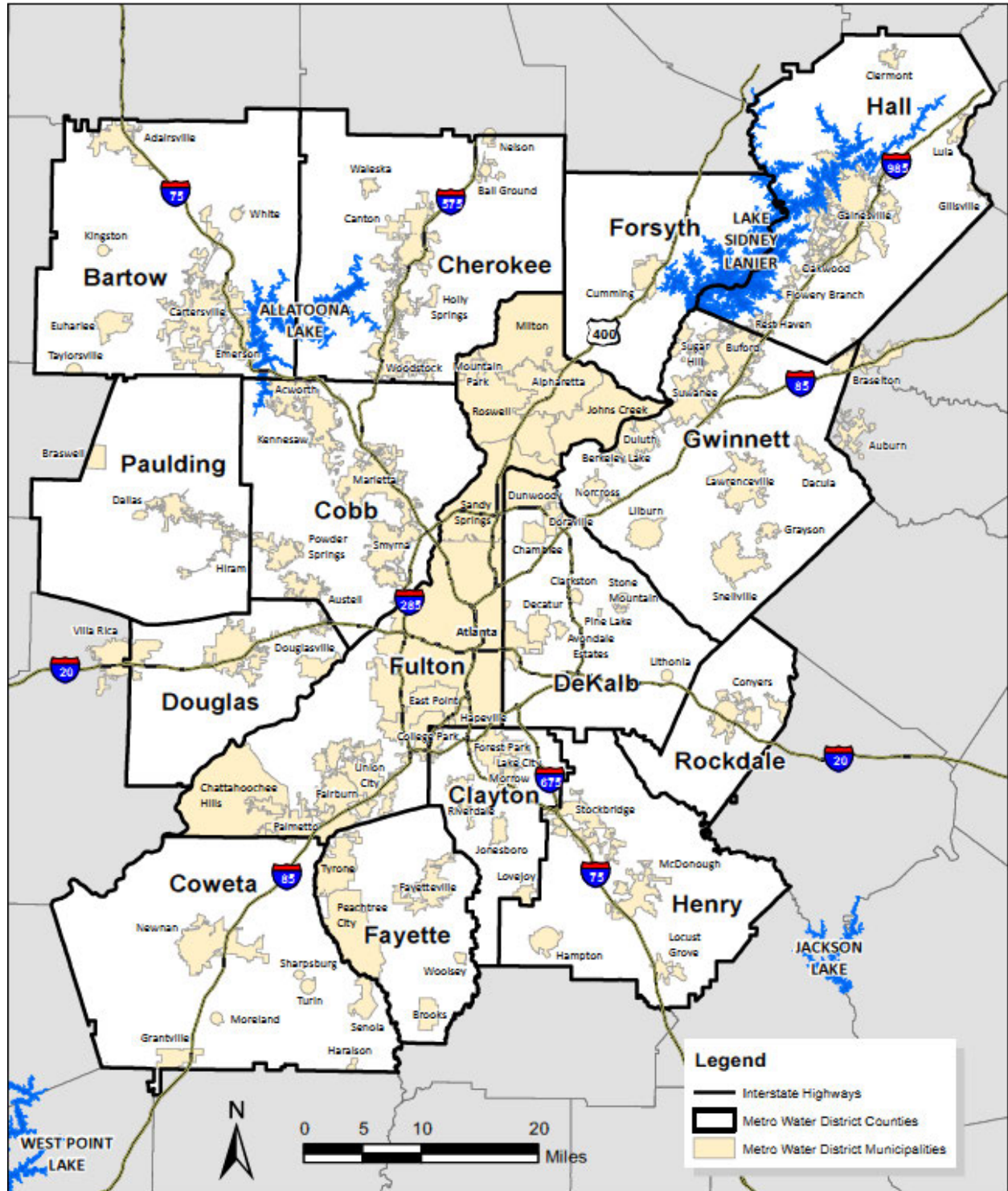
27 With the adoption of the SWP by the Georgia General Assembly in 2008, the MNGWPD became one of
28 10 regional water planning councils in the state. Accordingly, the work of the MNGWPD will continue
29 within the integrated framework of statewide water resources planning.

30 The MNGWPD enabling legislation mandated the development of three long-term regional plans to
31 address the water resources challenges:

- 32 • Water Supply and Water Conservation Management Plan
- 33 • Wastewater Management Plan
- 34 • Watershed Management Plan

35 These three plans were developed concurrently, and they represent an integrated and holistic approach to
36 water resources planning and management in the District (MNGWPD 2008).

1



2

3

Figure 1. Metro North Georgia Water Planning District Area.

1 The first plans were completed and adopted in 2003 and have been actively implemented by local
 2 jurisdictions in the MNGWPD. Updates to these plans were completed and published in May 2009
 3 (MNGWPD 2008). The following paragraphs summarize the detailed strategies and recommendations for
 4 both effective water supply and water conservation as defined in the 2009 update to the Water Supply and
 5 Water Conservation Management Plan. The plan includes specific tasks and milestones for implementing
 6 these recommendations for local governments as well as regional and state agencies. The MNGWPD
 7 water resources plans are the result of a collaborative effort between the District's local jurisdictions, the
 8 Georgia EPD, and numerous stakeholders.

9 **Existing Water Supplies.** The MNGWPD relies primarily on surface water from rivers and storage
 10 reservoirs as its main source of water supply. In fact, surface water provides over 99 percent of the water
 11 supply in the District. Groundwater use makes up less than 1 percent of the public water supplies for the
 12 MNGWPD, due to bedrock geology. For the foreseeable future, it is expected that the percentage of
 13 groundwater use will remain fairly constant. Groundwater supply sources remain viable as a potential
 14 source for small towns and as a supplemental source during critical periods. Within the MNGWPD,
 15 almost 888 average annual day-million gallons per day (aad-mgd) of permitted water supply (surface and
 16 groundwater) is available. The Chattahoochee basin accounts for approximately 73 percent of the
 17 permitted available water supply in the MNGWPD. A summary of existing permitted monthly average
 18 available water supply by basin is presented in Table 4.

19 **Table 4.**
 20 **MNGWPD percent permitted**
 21 **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%

22
 23 **Water Supply Interconnections.** Water supply service and management throughout the MNGWPD is
 24 provided by over 50 individual water providers. Water management includes supply, treatment,
 25 distribution, interconnections, and the interaction of these infrastructure systems with the natural systems.
 26 All 15 counties within the MNGWPD maintain interconnections with at least one other county for routine
 27 or emergency water sale. Some of these interconnections originally served as a primary water supply
 28 source before the water system in the receiving county was adequately developed. These connections are
 29 now kept for emergency uses. Interconnections with other water systems provide a valuable means of
 30 increasing water system reliability.

1 **Interbasin Transfers.** Interbasin transfers of water and wastewater occur among municipalities, counties,
 2 and basins in the MNGWPD. Transfers among basins are particularly common within counties that
 3 straddle the ridges between two or more basins. Interbasin transfers are a key and necessary element in
 4 supplying water throughout the MNGWPD; there are water supply and wastewater transfers into and out
 5 of every basin. Table 5 summarizes the existing water and wastewater interbasin transfers in the
 6 MNGWPD. The large net transfer from the Chattahoochee River basin to the Ocmulgee River basin is
 7 principally because of water withdrawals and returns in Gwinnett and DeKalb counties. While Lake
 8 Lanier (Gwinnett) and the Chattahoochee River (DeKalb) serve as primary water supply sources for the
 9 counties, only about one-third of their service areas are in the Chattahoochee River Basin. Consequently,
 10 a disproportionate share of the water supply withdrawals from the Chattahoochee River Basin for those
 11 counties is discharged into the Ocmulgee River Basin as treated wastewater.

12 **Table 5.**
 13 **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

14 a. Transfers estimated based on 2006 actual withdrawals and discharges.

15 b. aad-mgd (average annual day-million gallons per day).

16 **Water Conservation Program.** Water conservation is a critical element in meeting the water supply needs
 17 in the MNGWPD. When fully implemented, water conservation measures will reduce the MNGWPD's
 18 water demand by the end of the planning period. Much progress related to water conservation has been
 19 achieved since the adoption of the 2003 Water Supply and Water Conservation Management Plan. The
 20 MNGWPD's plan has been instrumental in making water conservation a priority in north Georgia. The
 21 MNGWPD is the only major metropolitan area in the country with more than 100 jurisdictions that is
 22 implementing such a comprehensive long-term water conservation program that is required and enforced.

23 The planning process reflected in the 2009 update to the MNGWPD's Water Supply and Water
 24 Conservation Management Plan first considered water conservation/efficiency before investigating new
 25 or expanded sources. The water conservation program in the 2009 plan is the result of extensive analysis
 26 of the 2003 program, evaluation of new methods and measures, and stakeholder involvement. Forty-five
 27 potential water conservation measures were identified and evaluated. Each potential conservation measure
 28 was ranked against three qualitative criteria—technology/market maturity, service area match, and
 29 customer acceptance/equity. The analysis detailed in the 2009 Plan update yielded a combination of
 30 measures that best met the ranking criteria and were determined to be cost-effective. The water
 31 conservation measures in this Plan update include and extend beyond the measures in the 2003 Plan. This
 32 update includes –

33 The 10 water conservation measures from the 2003 plan:

- 34 • Conservation pricing
- 35 • Replace older, inefficient plumbing fixtures
- 36 • Pre-rinse spray valve retrofit education program
- 37 • Rain sensor shutoff switches on new irrigation systems
- 38 • Sub-meters in new multifamily buildings

- 1 • Assess and reduce water system leakage
- 2 • Conduct residential water audits
- 3 • Distribute low-flow retrofit kits to residential users
- 4 • Conduct commercial water audits
- 5 • Implement education and public awareness plan

6 Strengthening three of these 10 water conservation measures:

- 7 • Irrigation meter pricing at 200 percent of the first-tier rate
- 8 • 1.28 gpf (gallons per flush) toilet rebate program only by 2014
- 9 • Minimum local education requirements and optional toolbox of examples is provided

10 Two new water conservation measures were added:

- 11 • Install 1.28 gpf toilets and low-flow urinals in government buildings
- 12 • Require new car washes to recycle water

13 Tiered water conservation rates (where the more water used, the higher the price) have been put in place
 14 throughout the MNGWPD. By 2008, more than 99 percent of the population was subject to increasing
 15 block or tiered rates. All of the largest water systems have implemented programs to reduce system water
 16 loss. Toilet rebate programs are in place and ahead of schedule. In 2008, twenty-four water providers
 17 offered toilet rebates to eligible customers, either directly or as part of the MNGWPD's regional toilet
 18 rebate program.

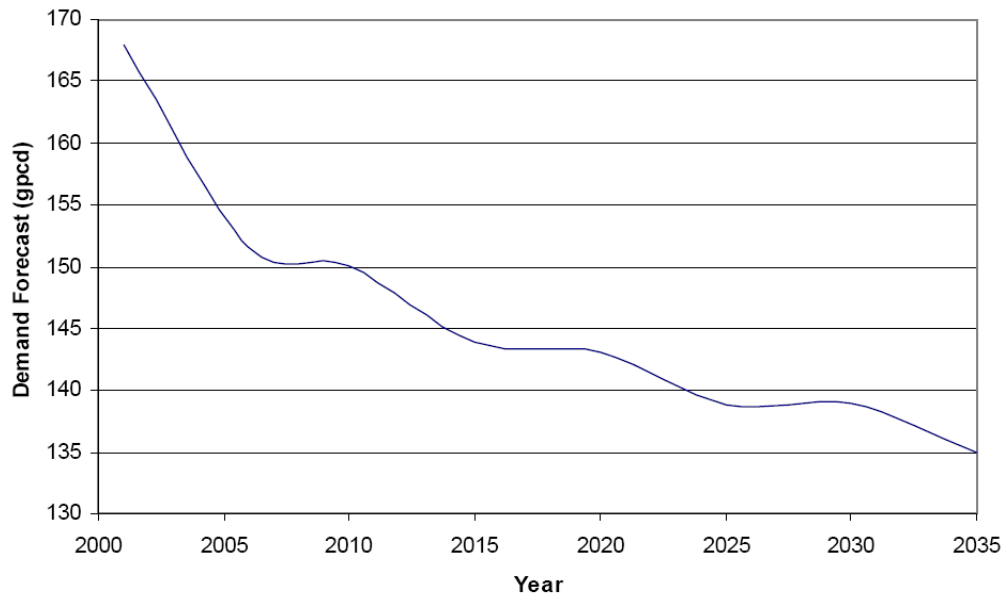
19 Figure 2 shows that the 2009 MNGWPD plan update projects a 20 percent reduction in per capita demand
 20 from 2001 to 2035 (MNGWPD 2009). The starting point of 168 gallons per capita per day (gpcd) reflects
 21 billing data for 2001 collected for the 2003 Plan. The 2006 data shows 151 gpcd, used in the plan update.
 22 By 2020, per capita water use in the MNGWPD is projected to be about 143 gpcd. The end point
 23 (135 gpcd) in 2035 reflects the benefit of the conservation program in the plan update.

24 Note that studies subsequent to the 2009 Water Supply and Conservation Plan indicate that per capita use
 25 in the MNGWPD area has declined faster than the earlier projected rates (Maddaus and CH2M Hill
 26 2011). This more rapid decline in per capita water use in the area is principally due to increased water use
 27 restrictions and conservation measures associated with the 2006-2008 drought which have become more
 28 institutionalized as well as the effect of the economic recession (beginning in 2008-2009). Water use in
 29 most of the MNGWPD has not returned to pre-2007 levels.

30 ***Future Water Supply Demands and Sources.*** With implementation of the enhanced water conservation
 31 program, the projected water demand within the MNGWPD is estimated to be 1,011 mgd by the year
 32 2035 on an average annual daily demand basis. Figure 3 depicts present and projected future permitted
 33 water supplies and water demands, both with and without the enhanced water conservation measures. The
 34 current permitted surface water supply is 882 aad-mgd. With the conservation program, 2020 water
 35 demands are estimated to be about 810 aad-mgd. According to Figure 3, the current level of EPD-
 36 permitted water supply would meet demands (with enhanced conservation) through about 2026. The
 37 MNGWPD considered the benefits of the water conservation program (reduction in demand) before
 38 considering additional water supply sources.

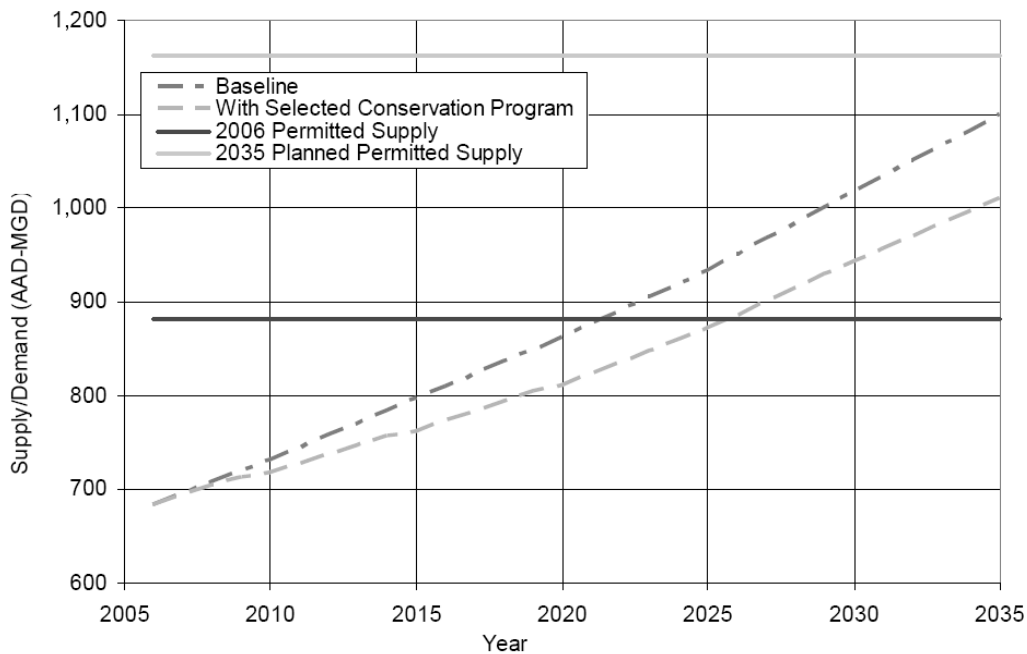
39 To meet projected future water supply needs in the MNGWPD beyond 2026 through the 2035 planning
 40 period, additional water supply sources will be needed. The anticipated 2035 permitted surface water
 41 supply is 1,160 aad-mgd. Future water supply alternatives to meet 2035 demands within the MNGWPD
 42 include expanded use of existing water supply sources and reservoirs and construction of six additional

1 water supply reservoirs; three are in the planning stages, and three others are needed within the planning
 2 horizon. Table 6 presents information on the six proposed reservoirs within the Metro North District. Two
 3 of those reservoirs (Bear Creek and Glades Reservoirs) are within the ACF Basin.



4 Source: MNGWPD 2009

5
 6 **Figure 2. Metro North Georgia Water District overall per capita water use trends (2001–2035) where**
 7 **overall per capita use is the total water demand supplied by public water systems in the MNGWPD**
 8 **divided by the MNGWPD’s population.**



9 Source: MNGWPD 2009

10
 11 **Figure 3. Metro North Georgia Water District water demand and supply.**

1
2

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.

3 Source: MNGWPD 2009

4 **Water Reuse.** Several types of water reuse may be used in the MNGWPD to extend supplies or replace
5 potential new water sources. The District plan outlines the different types of water reuse and discusses
6 existing and future applications identified within the District to meet the 10 percent reuse planning
7 standard identified by the Georgia EPD.

8 Non-potable reuse and indirect potable reuse are both practiced in the MNGWPD and are expected to
9 sustain water supplies into the future. Indirect potable reuse is highly encouraged, where appropriate.
10 Non-potable reuse is acceptable depending on each local community's consumptive use challenges, when
11 it offsets an existing potable water supply.

12 Long-term sustainability of the water resources in the upper ACF Basin can be achieved through
13 returning reclaimed water to Lake Lanier. The Metro District's Wastewater Management Plan calls for
14 cities and counties that withdraw water from Lake Lanier for drinking water supply to maximize the
15 return of reclaimed water to the lake. Summing both planned and incidental indirect potable reuse,
16 communities plan to return more than 100 aad-mgd to Lake Lanier within the 2035 planning horizon,
17 outlined in the District's Wastewater Management Plan.

18 The MNGWPD has assumed in its planning efforts to date that the federal reservoirs (Lake Lanier in the
19 ACF Basin and Lake Allatoona in the Alabama-Coosa-Tallapoosa [ACT] Basin) will continue to operate
20 to meet water supply needs within the District consistent with the guidance about future yield
21 expectations provided by the Georgia EPD.

22 More information on the MNGWPD program is available at <http://www.northgeorgiawater.org/>. The
23 2009 Water Supply and Conservation Plan document is available at
24 <http://www.northgeorgiawater.org/plans/water-supply-and-water-conservation-management-plan>.

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

1 While there is no way to prevent a drought from occurring, the adverse effects of a drought can be
2 reduced or mitigated through the implementation of the plan. The impact of drought can be reduced by
3 improving the overall forest health, which reduces the risk of drought-caused fires; improving and
4 maintaining water systems, which will reduce pumping failures; establishing and implementing
5 contingency plans (such as predetermined water conservation measures); or designating alternative
6 emergency water sources.

7 The plan creates a statewide regional structure to identify the different areas affected by drought
8 conditions; identify risks associated with drought conditions; identify ways to possibly avoid droughts;
9 and, when drought emergencies cannot be avoided, identify ways to mitigate the impacts of droughts.
10 These objectives are accomplished by developing drought triggers and indicators and by providing
11 guidance on responses to drought conditions for the various sectors affected by droughts.

12 In the plan, the Alabama Drought Assessment and Planning Team (ADAPT) has been established to serve
13 in an advisory capacity to Alabama OWR and the Governor's Office, as needed, and to coordinate
14 intergovernmental drought response and management in the implementation of all drought-related
15 activities. ADAPT is composed of members from several Alabama agencies, the U.S. Department of
16 Agriculture (USDA), the chairman of the Monitoring Advisory Committee (MAG), and the chairman of
17 the Drought Impact Group (DIG). The MAG provides technical support to ADAPT and is composed of
18 representatives from federal, state, and local agencies and other water resources professionals. The DIG
19 provides drought impact and mitigation support to ADAPT, is responsible for identifying drought impacts
20 on water users, and is representative of the following five drought impact sectors: domestic, agricultural,
21 environmental, industrial, and recreational. Each subgroup comprises state, local, private, and nonprofit
22 organizations and works on issues that encompass more than one drought sector.

23 The state is divided into nine specific regions, and drought indicators have been determined for each
24 region. When the drought indicators begin to show the potential onset of drought conditions, the Alabama
25 OWR, in coordination with ADAPT and the MAG, declares appropriate drought stage determinations
26 with increasing levels of severity (advisory, watch, warning, emergency) as the drought deepens.

27 Upon the inception of a new or increased drought alert phase, the ADAPT is responsible for
28 disseminating public information concerning all aspects of the drought. The initial action in responding to
29 drought must be public education—providing information as to existing and potential conditions and
30 water conservation measures necessary to meet the demand presented at each drought watch phase.

31 Drought triggers do not automatically invoke a required response from the various categories of water
32 users. The triggers do prompt additional monitoring and notices to the water systems and public regarding
33 the ongoing drought conditions. The Alabama OWR, in coordination with ADAPT, notifies the local
34 governments and water utilities regarding the severity of the drought, makes recommendations, and
35 provides guidance on the appropriate actions to be taken during the four stages of drought.

36 The Alabama Drought Management Plan is available at
37 <http://www.adeca.alabama.gov/Divisions/owr/Documents/ALDroughtPlan.pdf>.

38 **2.3 Alabama Water Use Reporting Program**

39 The Alabama OWR is mandated to administer Alabama's Water Use Reporting Program. This program
40 requires that major non-public and irrigation water users that have the capacity to withdraw at least
41 100,000 gal/d of surface water and/or groundwater, as well as all public water systems, register their use
42 with the Alabama OWR. Users are not required to obtain water withdrawal permits (ALOWR 2010).

1 Detailed information on the water use reporting program is available at
2 <http://adeca.alabama.gov/Divisions/owr/Pages/WaterManagement.aspx>.

3 **2.4 Water Conservation Program**

4 In addition to the Alabama Drought Management Plan, which specifically supports conservation efforts
5 during periods of drought, the state actively encourages voluntary water conservation/water efficiency
6 initiatives on the Alabama OWR web site (ALOWR 2010). The web site promotes and maintains
7 conservation tips on indoor and outdoor water use. The tips include links to assist (1) residential
8 customers to investigate water-saving opportunities in each area of the home; (2) agricultural interests to
9 consider adapting conservation practices that are used on agricultural land across the country to conserve
10 and improve natural resources for use on their land; and (3) municipal water planners with step-by-step
11 approaches and conservation measures that can be used to develop and implement plans for water
12 conservation. The web site also provides a sample Water Conservation Ordinance for use by municipal
13 and county government officials.

14 More information on the water conservation program is at
15 <http://adeca.alabama.gov/Divisions/owr/Pages/Drought.aspx#Water>.

16 **2.5 Alabama Water Agencies Working Group (AWAWG)**

17 In August 2011, Governor Bentley called together four agencies of state government with water resource
18 responsibilities to develop an overview of water issues and activities. The four agencies included:
19 Alabama Department of Community Affairs, Office of Water Resources (ALOWR); Alabama
20 Department of Conservation and Natural Resources (ADCNR); Alabama Department of Environmental
21 Management (ADEM); and the Geological Survey of Alabama (GSA). The Governor decided in April
22 2012 to continue and expand this work by formalizing the Alabama Water Agencies Working Group
23 (AWAWG). Soon thereafter, a fifth agency, the Alabama Department of Agriculture and Industries, was
24 added to the AWAWG.

25 Governor Bentley directed the AWAWG to recommend an action plan and timeline for implementing a
26 statewide water management plan by December 1, 2013. As part of the action plan process, AWAWG
27 was tasked to establish a comprehensive database of Alabama's water resources and conduct meetings to
28 gather input from stakeholders interested in water resource issues. The work of the AWAWG is
29 coordinated by a chairman appointed by the Governor. Six subcommittees were created to help carry out
30 the group's responsibilities and provide focus to the following specific topics: legal; database;
31 stakeholders; legislation; reporting; and public information.

32 AWAWG prepared and submitted a report to the Governor on August 1, 2012 entitled *Water*
33 *Management Issues in Alabama* (AWAWG 2012). The report represented an interim step in response to
34 the Governor's directive. It identified and summarized a dozen key water issues for the state and
35 associated policy options. The water and related issues identified included:

- 36 • Water Resources Management Plan
- 37 • Expanded Certificates of Use / Permitting
- 38 • Economic Development
- 39 • Surface Water and Groundwater Availability
- 40 • Drought Planning
- 41 • Water Conservation and Water Reuse
- 42 • Interbasin Transfers

-
- 1 • Instream Flows
 - 2 • Interstate Coordination
 - 3 • Water Resources Data
 - 4 • Key Stakeholder Education and Outreach
 - 5 • Public Education and Outreach

6 AWAWG reaffirmed the need for a statewide water management plan so that Alabama can address these
7 issues responsibly and effectively. The August 2012 report was intended to provide a common base of
8 information to assist various water agencies and others interested in water resource matters to take the
9 first steps toward resolving policy issues and creating a comprehensive water management plan for
10 Alabama.

11 The December 2013 report responding to the Governor’s directive summarized actions taken by
12 AWAWG through the August 2012 *Water Management Issues in Alabama* report and subsequent steps to
13 develop and recommend a conceptual framework for a comprehensive state-wide water resource
14 management plan. The recommendations were developed with substantial stakeholder participation. The
15 conceptual framework included a vision statement, guiding principles, and an action plan addressing all
16 twelve water resource issue areas identified in the August 2012 report. Recommended actions to
17 implement a state-wide water management plan included the following considerations: identification of
18 responsible agencies; estimated costs; relative priorities; and proposed timelines for implementation
19 (AWAWG 2013).

20 More detailed information on AWAWG is available at
21 <http://adeca.alabama.gov/Divisions/owr/awawg/Pages/default.aspx>.

1 **3 Florida**

2 **3.1 Florida Water Plan**

3 The Florida Water Plan is the Florida DEP's principal planning tool for long-term protection of the state's
4 water resources (FLDEP 2001). It was developed pursuant to section 373.036, Florida Statutes (F.S.),
5 which requires that it specifically include:

- 6 • The programs and activities of the Department related to water supply, water quality, natural
7 systems, flood protection, and floodplain management
- 8 • The water quality standards of the Department
- 9 • The District Water Management Plans (including regional water supply plans) of the five regional
10 water management districts
- 11 • The Water Resource Implementation Rule (Ch. 62-40, Florida Administrative Code)

12 Florida has a system of five regional water management districts under the general supervision of the
13 Florida DEP. Together, DEP and the water management districts share a broad range of responsibilities
14 related to water supply, flood protection and floodplain management, water quality, and protection of
15 natural systems. This system strikes a balance between the need for statewide consistency and the need
16 for regional flexibility. Figure 4 is a graphic representation of this system.

17 The plan is intended to help DEP, especially the Division of Water and the six DEP regulatory districts, to
18 focus on the highest water resource protection priorities, organize its own water management
19 responsibilities, and build water management partnerships. It identifies significant water resource
20 management priorities facing the state and sets forth strategies and actions for addressing them.
21 Specifically, the plan:

- 22 • Identifies what the DEP regards as the priority water issues
- 23 • States the DEP's main strategies for addressing the priority issues
- 24 • Focuses on accountability and performance measures
- 25 • Emphasizes the use of watershed management to achieve the DEP's water resource protection
26 goals and aids in the statewide development and coordination of the watershed management
27 approach
- 28 • Emphasizes the best use of current information technology to set priorities, assess effectiveness,
29 and improve public access to data pertaining to protection activities identified in the plan
- 30 • Seeks to strengthen partnerships with the water management districts and other parties

31 Each year the DEP reports on the progress of the specific action steps provided in the Florida Water Plan,
32 as well as other performance measures found in the plan. Typically the performance measures evaluate
33 environmental health or track the accomplishment of specific tasks.

34 The Florida Water Plan web site is <http://www.dep.state.fl.us/water/waterpolicy/fwplan.htm>.



1
2

Figure 4. Florida Water Management Plan.

1 3.1 Water Conservation

2 In 2001, during one of the worst droughts in Florida’s history, the DEP began an initiative to identify
3 additional measures to increase water use efficiency. The initiative was an open process in which the
4 DEP, in close coordination with the state’s five water management districts, facilitated public meetings to
5 develop specific water conservation recommendations. The final report (April 2002) contained 51 priority
6 recommendations for improving water use efficiency and led to a *Joint Statement of Commitment for the
7 Development and Implementation of a Statewide Comprehensive Water Conservation Program for Public
8 Water Supply* (JSOC). The JSOC is a written agreement by key public water supply partners in Florida to
9 collaborate on measures to improve water use efficiency.

10 Subsequent to the signing of the JSOC, and based on it, the 2004 regular session of the Florida
11 Legislature enacted House Bill 293. Among other things, the bill creates a new section 373.227, F.S.,
12 encouraging the use of efficient, effective, and affordable water conservation measures, and it states that a
13 goal-based, accountable, tailored water conservation program should be emphasized for public water
14 supply utilities (FLDEP 2004).

15 In the legislation, the DEP was directed to “develop a comprehensive statewide water conservation
16 program for public water supply.” That is to be done “in cooperation with the water management districts
17 and other stakeholders.” The legislative action affirmed the collaborative approach used in the JSOC. The
18 legislation was enacted to support and provide guidance to the general direction that the JSOC signatories
19 had already embarked upon. In addition to paraphrasing portions of the JSOC and authorizing the Florida
20 DEP and the water management districts to adopt rules needed to carry out the intended purpose, the
21 legislation required that a written report be submitted to the Florida Legislature by December 1, 2005
22 (FLDEP 2004).

23 On the basis of the principles of the JSOC, the signatories developed a work plan (completed in
24 December 2004). The work plan details the specific tasks, interim milestones, completion dates, estimated
25 costs and potential funding sources, and assignment of responsibilities to (FLDEP 2004):

- 26 • Develop standardized definitions and performance measures for water conservation data
27 collection and analysis
- 28 • Establish a clearinghouse for water conservation programs and practices
- 29 • Develop and implement a standardized process for public supply utilities to participate in the
30 statewide water conservation program for public supply
- 31 • Develop and maintain a Florida-specific water conservation guidance document to assist public
32 water suppliers in designing and implementing a utility-specific water conservation program
- 33 • Implement pilot projects through cooperative agreements with volunteer utilities
- 34 • The following DEP web site contains additional information on JSOC and state water
35 conservation policies: <http://www.dep.state.fl.us/water/waterpolicy/conservation.htm> .

36 3.2 Conserve Florida Water Clearinghouse

37 The Conserve Florida Water Clearinghouse is hosted by the University of Florida and supported by the
38 water management districts, the Florida DEP, and several associations and public utilities in the state with
39 an interest in water resource conservation. The mission of the Clearinghouse is to develop collaborative
40 relationships with related programs and to collect, analyze, and make available reliable information and
41 technical assistance to public water supply utilities and water managers for use in developing effective
42 and efficient water conservation programs (University of Florida 2010).

1 The Conserve Florida web site is <http://www.conservefloridawater.org/>.

2 **3.3 Northwest Florida Water Management District (NFWWMD)**

3 The NFWWMD is one of five water management districts in the state created by the Water Resources Act
 4 of 1972. The water management districts are directly responsible for managing the quality and quantity of
 5 the state's waters in conjunction with the Florida DEP. The NFWWMD has worked for decades to protect
 6 and manage water resources in a sustainable manner for the continued welfare of people and natural
 7 systems across its 16 county region. The NFWWMD serves the following Florida counties: Bay,
 8 Calhoun, Escambia, Franklin, Gadsden, Gulf, Holmes, Jackson, Leon, Liberty, Okaloosa, Santa Rosa,
 9 Wakulla, Walton, Washington, and western Jefferson. The NFWWMD area of responsibility is depicted
 10 on Figure 5, which includes the Apalachicola River and Bay.



11
 12 **Figure 5. Northwest Florida Water Management District (NFWWMD 2005)**

13 **3.3.1 District Water Management Plan**

14 Pursuant to section 373.036, Florida Statutes, the NFWWMD develops a Strategic Water Management
 15 Plan (SWMP) every five years to define the responsibilities of the District, as well as the agency's
 16 objectives, strategies and success criteria. This plan focuses on current strategies – those activities the
 17 District plans to undertake in the near term to accomplish its mission to protect and manage the water
 18 resources of northwest Florida in a sustainable manner for the continued welfare of its residents and
 19 natural systems. The plan defines the District's current strategic priorities, implementation activities,
 20 financial resources and performance measures. The most recent published version of the SWMP occurred
 21 in 2010.

1 Prior to 2006, the water management districts in Florida developed District Water Management Plans
 2 (DWMPs) and update them every 5 yr. The last update to the NFWFMD DWMP was completed in 2005
 3 (NFWFMD 2005). The planning processes outlined below that were part of the DWMPs are now
 4 captured in the Strategic Water Management Annual Work Plan Report. The SWMP integrates major
 5 programs, including regional water supply planning, water resource development, water supply
 6 development assistance, minimum flows and levels, resource regulation, wetland mitigation, special
 7 projects, the Surface Water Improvement and Management program, technical assistance, land acquisition
 8 and management, and public outreach and education. Detailed District work plans and documents guide
 9 the implementation of these programs. Collectively, the District's programs and plans, and its budget,
 10 constitute a comprehensive approach to the interrelated issues that span the four major areas of
 11 responsibility (AORs):

- 12 1. **Water Supply.** *Promote the availability of sufficient water for all existing and future reasonable-*
 13 *beneficial uses and affected natural systems.* The District works with local governments, utilities,
 14 and state and federal agencies to plan appropriately for, and ensure the availability of, sufficient
 15 water supplies in a manner that meets the needs of the human community and sustains associated
 16 natural systems.
- 17 2. **Flood Protection and Floodplain Management.** *Maintain natural floodplain functions and*
 18 *minimize harm from flooding.* Emphasizing a nonstructural approach, including land acquisition
 19 and mapping of flood-prone areas, the District works to protect and, where necessary, restore
 20 natural floodplain functions and help to protect the health, safety, and welfare of the region's
 21 residents and the integrity of the region's natural systems.
- 22 3. **Water Quality.** *Protect and improve the quality of the District's water resources.* The District
 23 works with local governments, state and federal agencies, and regional stakeholders to protect
 24 and, where necessary, restore water quality.
- 25 4. **Natural Systems.** *Protect and enhance natural systems.* The District works in cooperation with
 26 state and federal agencies, local governments, and regional stakeholders to protect natural
 27 resources of regional significance in a comprehensive, integrated manner, to preserve and restore
 28 natural systems and maintain public benefits and compatible uses.

29 The DWMP communicates the District's most pressing water management issues and its key strategies to
 30 address them. Intergovernmental coordination is critical to the District in carrying out its responsibilities.
 31 The District forms partnerships with other levels of government that implement water management
 32 through planning, regulation, and acquisition, and service delivery programs. By maintaining close
 33 working ties with federal, state, regional, and local agencies, the District can draw upon and provide
 34 important resources, technical expertise, and knowledge to support effective water resource management
 35 and implementation of the plan.

36 The 2010 Strategic Water Management Plan is available at
 37 <http://www.nwfwmd.state.fl.us/system/assets/832/original/SWMP2010-2011.pdf>.

38 **3.3.2 Consumptive Use Permits**

39 Through the Consumptive Use Program, the District's water supplies are allocated in a manner that is
 40 reasonable and beneficial, is in the public interest, and does not have a deleterious impact on existing
 41 legal users or the resource.

42 The NFWFMD operates regulatory programs that address, through rules, the consumptive use of water;
 43 the construction, repair, or abandonment of water wells and licensing of water well contractors; the safety
 44 of nonagricultural impoundments; agricultural and forestry surface water management facilities, including

1 *farm ponds*; stormwater management systems; the artificial recharge of groundwater; and works of the
2 District (NFWFMD 2010).

3 For consumptive use permitting purposes, the District is divided into three permitting areas within the
4 NFWFMD boundary—Permit Areas A, B, and C. The six counties along the Apalachicola River corridor
5 fall into the following permit categories: Gulf County (Area B, Area A for barrier islands); Franklin
6 County (Area B, Area A for barrier islands); Calhoun County (Area C); Jackson County (Area C); Liberty
7 County (Area B); and Gadsden County (Area A). Unless exempted by law or rule, the following criteria
8 are used for consumptive use permitting requirements (NFWFMD 2010):

9 ***Ground Water Withdrawals***

10 *Permit Area A*

- 11 • All non-exempt water uses regardless of well size or withdrawal amounts

12 *Permit Area B*

- 13 • Withdrawals that exceed an annual daily average of 100,000 gal; or
- 14 • Combined withdrawal capacity of the well(s) exceeds 1,000,000 gal/d; or
- 15 • Withdrawals from a well(s) 6 in or larger in diameter; or
- 16 • Any withdrawal for community public supply or bottled water use

17 *Permit Area C*

- 18 • Withdrawals that exceed 1,400,000 gal in any single day; or
- 19 • Withdrawals from a well(s) 10 in or larger in diameter; or
- 20 • Any withdrawal for community public supply or bottled water use

21 ***Surface Water Withdrawals (Regardless of Location)***

- 22 • Withdrawals from a lake, pond, river, stream, or impoundment that exceed an average daily
23 withdrawal of 100,000 gal, or exceed 1,000,000 gal on any single day or 10 percent of the
24 baseflow of the supplying waterbody; or
- 25 • In Gadsden County, in addition to the above thresholds, surface water withdrawals using a pipe(s)
26 or combination of pipes whose outside diameter(s) equals 4 in or larger; or
- 27 • Any withdrawal for community public supply or bottled water use

28 More information on water use permits in the NFWFMD area is available at
29 <http://www.nwfwmd.state.fl.us/permits>.

30 The NFWFMD web site is <http://www.nwfwmd.state.fl.us>.

31

1 References

- 2 ALOWR (Alabama Office of Water Resources). 2010. Welcome to OWR.
3 <adeca.alabama.gov/Office%20of%20Water%20Resources/default.aspx>. Accessed February 2010.
- 4 ALOWR (Alabama Office of Water Resources). 2013. *Alabama Drought Management Plan (Final)*.
5 <<http://adeca.alabama.gov/Divisions/owr/Documents/ALDroughtPlan.pdf>>. Accessed July 2014.
- 6 AWAAG (Alabama Water Agencies Working Group). 2012. *Water Management Issues in Alabama: A*
7 *Report to the Honorable Governor Robert Bentley, Governor of Alabama*.
8 <http://adeca.alabama.gov/Divisions/owr/awawg/Documents/2012_08_31%20AWAG_Water_Issue_Report_31.pdf>. Accessed September 2012.
- 10 AWAAG (Alabama Water Agencies Working Group). 2013. *Mapping the Future of Alabama Water*
11 *Resources Management: Policy Options and Recommendations – A Report to the Honorable Robert*
12 *Bentley, Governor of Alabama*.
13 <<http://www.adeca.alabama.gov/Divisions/owr/awawg/Documents/AWAAG-Report-FINAL-2-Side-Print.pdf>>. Accessed May 2014.
- 15 Cowie, G., and D. Davis. 2009. *Georgia's State Water Plan*. Georgia State University, Robinson School
16 of Business, Atlanta, Georgia.
- 17 CRS (Congressional Research Service). 2008. *Apalachicola-Chattahoochee-Flint (ACF) Drought:*
18 *Federal Water Management Issues*. CRS Report for Congress, Order Code RL34326. Congressional
19 Research Service, Washington, D.C.
- 20 FLDEP (Florida Department of Environmental Protection). 2001. *Florida Water Plan—Implementing*
21 *Watershed Management*. Florida Department of Environmental Protection, Tallahassee, Florida.
- 22 FLDEP (Florida Department of Environmental Protection). 2004. Work Plan to Implement Section
23 373.227, F.S. (Section 8 of House Bill 293) and the Joint Statement of Commitment for the
24 Development and Implementation of a Statewide Comprehensive Water Conservation Program for
25 Public Water Supply. Florida Department of Environmental Protection, Northwest District,
26 Tallahassee, Florida.
- 27 GADNR (Georgia Department of Natural Resources). 2006. *Flint River Basin Regional Water*
28 *Development and Conservation Plan*. Georgia Department of Natural Resources, Atlanta, Georgia.
- 29 GADNR (Georgia Department of Natural Resources). 2009a. *Georgia's Water Conservation*
30 *Implementation Plan*. Georgia Department of Natural Resources, Environmental Protection Division,
31 Atlanta, Georgia.
- 32 GADNR (Georgia Department of Natural Resources). 2009b. *Conserve Water Georgia: Water*
33 *Conservation Clearinghouse*. <www.conservewatergeorgia.net/index.html>. Accessed February
34 2010.
- 35 GAEPD (Georgia Environmental Protection Division). 2003. *Georgia Drought Management Plan*.
36 Georgia Environmental Protection Division, Department of Natural Resources, Atlanta, Georgia.
- 37 GAEPD (Georgia Environmental Protection Division). 2004. Rules of the Georgia Department of Natural
38 Resources, Environmental Protection Division, Chapter 391-3-30, Outdoor Water Use [Authority

- 1 O.C.G.A. Sections 12-5-90 et seq., 12-5-170 et seq.]. Georgia Environmental Protection Division,
2 Atlanta, Georgia.
- 3 GAEPD (Georgia Environmental Protection Division). 2006. *Flint River Basin Regional Water*
4 *Development and Conservation Plan*. Georgia Environmental Protection Division, Atlanta, Georgia.
- 5 GAEPD (Georgia Environmental Protection Division). 2008. *Georgia Comprehensive State-wide Water*
6 *Management Plan*. Georgia Environmental Protection Division, Department of Natural Resources,
7 Atlanta, Georgia.
- 8 GEFA (Georgia Environmental Facilities Authority). 2008. *Georgia Inventory and Survey of Feasible*
9 *Sites for Water Supply Reservoirs*. Georgia Environmental Facilities Authority, Atlanta, Georgia.
- 10 Hook, James E., Gerrit Hoogenboom, Joel Paz, Jeffrey Mullen, John Bergstrom, and Mark Risse. 2009.
11 *Agricultural Irrigation Water Demand, Georgia's Major and Minor Crops, 2011 through 2050*.
12 National Environmentally Sound Production Agriculture Laboratory (NESPAL), University of
13 Georgia, College of Agricultural and Environmental Sciences, Athens, Georgia.
- 14 Maddaus (Maddaus Water Management) and CH2M Hill. 2011. *National Water Use per Capita Survey,*
15 *2005-2007 Period*. Prepared for the Atlanta Regional Commission. Atlanta, Georgia. January 2009
16 (updated May 2011).
- 17 McDowell, R.J. 2005. Status of the Flint River Regional Water Development and Conservation Plan.
18 Paper presented at the 2005 Georgia Water Resources Conference, April 25–27, Georgia Center,
19 University of Georgia, Athens, Georgia.
- 20 MNGWPD (Metropolitan North Georgia Water Planning District). 2008. *2008 Activities & Progress*
21 *Report*. Metropolitan North Georgia Water Planning District, Atlanta, Georgia.
- 22 MNGWPD (Metropolitan North Georgia Water Planning District). 2009. *Water Supply and Conservation*
23 *Management Plan*. Metropolitan North Georgia Water Planning District, Atlanta, Georgia.
- 24 NFWWMD (Northwest Florida Water Management District). 2005. *District Water Management Plan;*
25 *Program Development Series 2005-1*. Northwest Florida Water Management District, Havana, Florida.
- 26 NFWWMD (Northwest Florida Water Management District). 2010. *Northwest Florida Water*
27 *Management District Permits*. Northwest Florida Water Management District, Havana, Florida.
- 28 Office of the Governor of Georgia. 2009. *Water Contingency Planning Task Force, Findings and*
29 *Recommendation*. Office of the Governor of Georgia, Atlanta, Georgia.
- 30 Torak, L.J. and R.J. McDowell. 1996. Ground-Water Resources of the Lower Apalachicola-
31 Chattahoochee-Flint River Basin in Parts of Alabama, Florida, and Georgia— Subarea 4 of the
32 Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basin. Open file report
33 95-321. U.S. Geological Survey, Reston, Virginia.
- 34 University of Florida. 2010. Conserve Florida Water Clearinghouse.
35 <<http://www.conservefloridawater.org/mission.asp>>. Accessed August 2010.
- 36 UGA (University of Georgia). 2010. *Policy Brief 2010: The Georgia Water Stewardship Act*. University
37 of Georgia, Carl Vinson Institute of Government, Athens, Georgia.

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Appendix H

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ACF Basin Species Lists

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Appendix H

Selected Tables Related to Section 2.5

- Table H-1. Mammals known or potentially occurring in riparian and upland portions of the ACF Basin
- Table H-2. Reptiles known or potentially occurring in at least a portion of the ACF Basin
- Table H-3. Amphibians known or potentially occurring in at least a portion of the ACF Basin
- Table H-4. Invertebrate taxa identified from 17 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 2009b)
- Table H-5. Distribution of fish, by river basin and ecoregion
- Table H-6. Partial list of phytoplankton species documented in Apalachicola Bay
- Table H-7. Partial list of fish species of the Apalachicola Bay Estuary
- Table H-8. A partial list of invertebrate taxa found in the Apalachicola Bay Estuary

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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
<i>Blarina brevicauda</i>	northern short-tailed shrew	<i>Nycticeius humeralis</i>	evening bat
<i>B. carolinensis</i>	southern short-tailed shrew	<i>Ochrotomus nuttalli</i>	golden mouse
<i>Canis latrans</i>	coyote	<i>Odocoileus virginianus</i>	white-tailed deer
<i>Castor canadensis</i>	American beaver	<i>Ondatra zibethicus</i>	muskrat
<i>Corynorhinus rafinesquii</i>	Rafinesque's big-eared bat	<i>Oryzomys palustris</i>	marsh rice rat
<i>Cryptotis parva</i>	least shrew	<i>Peromyscus gossypinus</i>	common mouse
<i>Dasypus novamcinctus</i>	nine-banded armadillo	<i>P. leucopus</i>	white-footed mouse
<i>Didelphus virginiana</i>	Virginia opossum	<i>P. polionotus</i>	oldfield mouse
		<i>Perimyotis subflavus</i>	Tricoloured bat
<i>Eptesicus fuscus</i>	big brown bat		
<i>Geomys pinetisa</i>	southeastern pocket gopher	<i>Procyon lotor</i>	common racoon
<i>Glaucomys volans</i>	southern flying squirrel	<i>Rattus norvegicus</i>	norway rat
<i>Lasionycteris noctivagans</i>	silver-haired bat	<i>R. rattus</i>	black rat
<i>Lasiurus borealis</i>	eastern red bat	<i>Reithrodontomys humulis</i>	eastern harvest mouse
<i>L. cinereus</i>	hoary bat	<i>Scalopus aquaticus</i>	eastern mole
<i>L. intermedius</i>	northern yellow bat	<i>Sciurus carolinensis</i>	eastern gray squirrel
<i>L. seminolus</i>	Seminole bat	<i>S. niger</i>	eastern fox squirrel
<i>Lutra canadensis</i>	northern river otter	<i>Sigmodon hispidus</i>	hispid cotton rat
<i>Lynx rufus</i>	bobcat	<i>Sorex longirostris</i>	southern shrew
<i>Marmota monax</i>	woodchuck	<i>Spilogale putorius</i>	eastern spotted skunk
<i>Mephitis mephitis</i>	striped skunk	<i>Sus scrofa</i>	wild pig
<i>Microtus pennsylvanicus</i>	meadow vole	<i>Sylvilagus aquatious</i>	swamp rabbit
<i>M. pinetorum</i>	woodland vole	<i>S. floridanus</i>	eastern cottontail
<i>Mus musculus</i>	house mouse	<i>S. palustris</i>	marsh rabbit
<i>Mustela frenata</i>	long-tailed weasel	<i>Tadarida brasiliensis</i>	Brazilian free-tailed bat
<i>M. vison</i>	mink	<i>Tamias striatus</i>	eastern chipmunk
<i>Myocastor coypus</i>	nutria	<i>Urocyon cinereoargenteus</i>	common gray fox
<i>Myotis austroriparius</i>	southeastern myotis	<i>Ursus americanus</i>	black bear
<i>M. grisescens</i>	gray myotis	<i>Vulpes vulpes</i>	red fox
<i>Napaeozapus insignis</i>	woodland jumping mouse	<i>Zapus hudsonicus</i>	meadow jumping mouse
<i>Neotoma floridana</i>	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
<i>Agkistrodon contortrix</i>	copperhead	<i>L. elapsoides</i>	scarlet king snake
<i>A. piscivorus</i>	cottonmouth	<i>L. getula</i>	common king snake ^a
<i>Alligator mississippiensis</i>	American alligator	<i>Macrolemys temmincki</i>	alligator snapping turtle
<i>Anolis carolinensis</i>	green anole	<i>Masticophis flagellum</i>	coach whip
<i>Apalone ferox</i>	Florida softshell	<i>Micrurus fulvius</i>	coral snake
<i>A. spinifera</i>	spiny softshell	<i>Nerodia erythrogaster</i>	plainbelly water snake ^b
<i>Carphophis amoenus</i>	worm snake	<i>N. fasciata</i>	banded water snake
<i>Cemaphora coccinea</i>	scarlet snake	<i>N. floridana</i>	Florida green water snake
<i>Chelydra serpentina</i>	common snapping turtle	<i>N. sipedon</i>	Midland water snake
<i>Chrysemys picta</i>	painted turtle	<i>N. taxispilota</i>	brown water snake
<i>Clemmys guttata</i>	spotted turtle	<i>Opheodrys aestivus</i>	rough green snake
<i>Cnemidophorus sexlineatus</i>	six-lined racerunner	<i>Ophisaurus attenuatus</i>	slender glass lizard
<i>Coluber constrictor</i>	black racer	<i>O. mimicus</i>	mimic glass lizard
<i>Crotalus adamanteus</i>	eastern diamondback rattlesnake	<i>O. ventralis</i>	Eastern glass lizard
<i>C. horridus</i>	canebrake timber rattlesnake	<i>Pituophis melano levcus</i>	pine snake
<i>Deirochelys reticularia</i>	chicken turtle	<i>Pseudemys concinna</i>	river cooter
<i>Diadophis punctatus</i>	ringneck snake	<i>P. floridana</i>	Florida cooter
<i>Drymarchon corais</i>	indigo snake	<i>Regina rigida</i>	glossy crayfish snake
<i>Elaphe obsoleta</i>	rat snake	<i>R. septembittata</i>	queen snake
<i>Eumeces anthracinus</i>	coal skink	<i>Sceloporus undulatus</i>	fence lizard
<i>E. egregius</i>	mole skink	<i>Scincella lateralis</i>	ground skink
<i>E. fasciatus</i>	five-lined skink	<i>Seminatrix pygaea</i>	black swamp snake
<i>E. inexpectatus</i>	southeastern five-lined skink	<i>Sistrurus miliarius</i>	pigmy rattlesnake
<i>E. laticeps</i>	broadhead skink	<i>Sternotherus minor</i>	loggerhead musk turtle
<i>Farancia abacura</i>	mud snake	<i>S. odoratus</i>	common musk turtle
<i>F. erythrogramma</i>	rainbow snake	<i>Storeria dekayi</i>	brown snake
<i>Gopherus polyphemus</i>	gopher tortoise	<i>S. occipitomaculata</i>	red-bellied snake
<i>Graptemys geographica</i>	common map turtle	<i>Tantilla coronata</i>	southeastern crowned snake
<i>G. polchra</i>	Alabama map turtle	<i>Terrapene carolina</i>	box turtle
<i>Heterodon platirhinos</i>	eastern hognose snake	<i>Thamnophis sauritus</i>	ribbon snake
<i>H. simus</i>	southern hognose snake	<i>T. sirtalis</i>	eastern garter snake
<i>Kinosternon baurii</i>	striped mud turtle	<i>Trachemys scripta</i>	common slider
<i>K. subrubrum</i>	eastern mud turtle	<i>Virginia striatula</i>	rough earth snake
<i>Lampropeltis calligaster</i>	mole kingsnake	<i>V. valeriae</i>	smooth earth snake

^aAlso known as black/eastern kingsnake; ^bAlso 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
<i>Acris crepitans</i>	northern cricket frog	<i>H. cinerea</i>	green treefrog
<i>A. gryllus</i>	southern cricket frog	<i>H. femoralis</i>	pine woods treefrog
<i>Ambystoma cingulatum</i>	flatwoods salamander	<i>H. gratiosa</i>	barking treefrog
<i>A. maculatum</i>	spotted salamander	<i>H. squirella</i>	squirrel treefrog
<i>A. opacum</i>	marbled salamander	<i>Necturus alabamensis</i>	Alabama waterdog
<i>A. talpoideum</i>	mole salamander	<i>Notophthalmus perstriatus</i>	striped newt
<i>A. tigrinum</i>	tiger salamander	<i>N. viridescens</i>	eastern newt
<i>Amphiuma means</i>	two-toed amphiuma	<i>Plethodon glutinosus</i>	slimy salamander complex
<i>Bufo americanus</i>	American toad	<i>P. serratus</i>	southern redback salamander
<i>B. fowleri</i>	Fowler's toad	<i>P. websteri</i>	Webster's salamander
<i>B. quercicus</i>	oak toad	<i>Pseudacris crucifer</i>	spring peeper
<i>B. terrestris</i>	southern toad	<i>P. feriarum</i>	upland chorus frog
<i>Cryptobranchus alleganiensis</i>	hellbender	<i>P. nisrita</i>	southern chorus frog
<i>Desmognathus aeneus</i>	seepage salamander	<i>P. ocularis</i>	little grass frog
<i>D. apalachicola</i>	Apalachicola dusky salamander	<i>P. ornata</i>	ornate chorus frog
<i>D. auriculatus</i>	southern dusky salamander	<i>Pseudobranchius striatus</i>	dwarf siren
<i>D. conanti</i>	spotted dusky salamander	<i>Pseudotriton montanus</i>	mud salamander
<i>D. monticola</i>	seal salamander	<i>P. ruber</i>	red salamander
<i>D. ocoee</i>	Ocoee salamander	<i>Rana capito</i>	gopher frog
<i>D. quadramaculatus</i>	blackbelly salamander	<i>R. calesbeiana</i>	american bullfrog
<i>Eurycea cirrigera</i>	southern two-lined salamander	<i>R. clamitans</i>	green frog/bronze frog
<i>E. gultolineata</i>	southern three-lined salamander	<i>R. grylio</i>	pig frog
<i>E. quadridigitata</i>	dwarf salamander	<i>R. heckscheri</i>	river frog
<i>Gastrophryne carolinensis</i>	eastern narrow mouth toad	<i>R. palustris</i>	pickerel frog
<i>Gyrinophilus porphyriticus</i>	spring salamander	<i>R. sphenoccephala</i>	southern leopard frog
<i>Haideotriton wallacei</i>	Georgia blind salamander	<i>R. sylvatiza</i>	wood frog
<i>Hemidactylium scutatum</i>	four-toed salamander	<i>Scaphiopus nolibroki</i>	eastern spadefoot toad
<i>Hyla avivoca</i>	bird-voiced treefrog	<i>Siren intermedia</i>	lesser siren
<i>H. chrysoscelis</i>	Cope's gray treefrog	<i>S. lacertina</i>	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 2009b)

Class	Order	Family	Genus	Common name
Acari	Trombidiformes	Hygrobatidae	<i>Hygrobates</i>	water mites
		Lebertiidae	<i>Lebertia</i>	water mites
		Arrenuridae	<i>Arrenurus</i>	water mites
		Pionidae	<i>Forelia</i>	water mites
		Unionicolidae	<i>Koenikea</i>	freshwater mites
			<i>Neumania</i>	freshwater mites
	Oxidae	<i>Oxus</i>	freshwater mites	
Crustacea	Amphipoda	Hyaellidae	<i>Hyaella</i>	scud
	Decapoda	Cambaridae		crayfish
		Palaemonidae	<i>Palaemonetes</i>	freshwater shrimp
	Isopoda	Asellidae	<i>Lirceus</i>	freshwater isopod
Insecta	Diptera	Psychodidae	<i>Psychoda</i>	moth flies
		Ceratopogonidae	<i>Bezzia/Palpomyia</i>	biting midges
			<i>Dasyhelea</i>	biting midges
			<i>Mallochohelea</i>	biting midges
			<i>Probezzia</i>	biting midges
		Chironomidae	<i>Ablabesmyia</i>	non-biting midges
			<i>Brillia</i>	non-biting midges
			<i>Chironomus</i>	non-biting midges
			<i>Cladopelma</i>	non-biting midges
			<i>Cladotanytarsus</i>	non-biting midges
			<i>Coelotanypus</i>	non-biting midges
			<i>Conchapelopia</i>	non-biting midges
			<i>Cricotopus</i>	non-biting midges
			<i>Cricotopus/Orthocladius</i>	non-biting midges
			<i>Cryptochironomus</i>	non-biting midges
			<i>Cryptotendipes</i>	non-biting midges
			<i>Demicryptochironomus</i>	non-biting midges
			<i>Dicrotendipes</i>	non-biting midges
			<i>Microtendipes</i>	non-biting midges
			<i>Nanocladius</i>	non-biting midges
			<i>Natarsia</i>	non-biting midges
		<i>Nilotanypus</i>	non-biting midges	
		<i>Nilothauma</i>	non-biting midges	
		<i>Parachironomus</i>	non-biting midges	
		<i>Paracladopelma</i>	non-biting midges	
		<i>Parakiefferiella</i>	non-biting midges	
		<i>Paralauterborniella</i>	non-biting midges	

Class	Order	Family	Genus	Common name
Insecta	Diptera	Chironomidae	<i>Parametriocnemus</i>	non-biting midges
			<i>Paratanytarsus</i>	non-biting midges
			<i>Paratendipes</i>	non-biting midges
			<i>Phaenopsectra</i>	non-biting midges
			<i>Polypedilum</i>	non-biting midges
			<i>Procladius</i>	non-biting midges
			<i>Pseudochironomus</i>	non-biting midges
			<i>Rheocricotopus</i>	non-biting midges
			<i>Rheosmittia</i>	non-biting midges
			<i>Rheotanytarsus</i>	non-biting midges
			<i>Robackia</i>	non-biting midges
			<i>Saetheria</i>	non-biting midges
			<i>Stelechomyia</i>	non-biting midges
			<i>Stempellina</i>	non-biting midges
			<i>Stempellinella</i>	non-biting midges
			<i>Stictochironomus</i>	non-biting midges
		<i>Tanytarsus</i>	non-biting midges	
		<i>Thienemannimyia</i>	non-biting midges	
		<i>Tribelos</i>	non-biting midges	
		<i>Xestochironomus</i>	non-biting midges	
		Dixidae	<i>Dixa</i>	dixids
		Empididae	<i>Hemerodromia</i>	empidids
		Simuliidae	<i>Simulium</i>	black flies
		Tabanidae	<i>Chrysops</i>	deer flies
		Tipulidae	<i>Hexatoma</i>	crane flies
	Megaloptera	Corydalidae	<i>Nigronia</i>	fishflies
	Coleoptera	Gyrinidae	<i>Dineutus</i>	whirligig beetles
		Dryopidae	<i>Helichus</i>	long-toed water beetles
		Elmidae	<i>Ancyronyx</i>	riffle beetles
			<i>Optioservus</i>	riffle beetles
			<i>Promoresia</i>	riffle beetles
			<i>Stenelmis</i>	riffle beetles
		Psephenidae	<i>Psephenus</i>	water penny beetles
		Hydrophilidae		water scavenger beetles
	Ephemeroptera	Ephemeridae	<i>Ephemera</i>	burrowing mayflies
			<i>Hexagenia</i>	burrowing mayflies
		Baetiscidae	<i>Baetisca</i>	mayflies
		Caenidae	<i>Caenis</i>	mayflies
		Baetidae	<i>Pseudocloeon</i>	mayflies
			<i>Baetis</i>	mayflies
		Isonychiidae	<i>Isonychia</i>	mayflies

Class	Order	Family	Genus	Common name
		Heptageniidae		flatheaded mayflies
	Odonata	Gomphidae	<i>Progomphus</i>	dragonflies
		Cordulegastridae	<i>Cordulegaster</i>	spiketails
		Coenagrionidae	<i>Argia</i>	narrow-winged damselflies
	Trichoptera	Hydropsychidae	<i>Ceratopsyche</i>	web-spinning caddis
			<i>Cheumatopsyche</i>	web-spinning caddis
			<i>Hydropsyche</i>	web-spinning caddis
			<i>Nectopsyche</i>	web-spinning caddis
			<i>Diplectrana</i>	web-spinning caddis
		Hydroptilidae	<i>Hydroptila</i>	microcaddisflies
		Philopotamidae	<i>Chimarra</i>	little black caddisflies
		Leptoceridae	<i>Oecetis</i>	long-horned sedges (caddisflies)
	Plecoptera	Leuctridae	<i>Leuctra</i>	tiny winter blacks (stoneflies)
		Perlidae	<i>Acroneuria</i>	common stoneflies
			<i>Perlinella</i>	striped stone (stoneflies)
Mollusca	Basommatophora	Ancylidae	<i>Ferrissia</i>	limpets
		Planorbidae	<i>Menetus</i>	ram's horn snails
		Physidae	<i>Physa</i>	bladder snails
	Veneroida	Corbiculidae	<i>Corbicula</i>	basket clams
		Sphaeriidae		finger nail clams
Oligochaeta	Lumbriculida	Lumbriculidae		segmented worms
	Haplotaxida	Naididae	<i>Nais</i>	segmented worms
			<i>Bratislavia</i>	segmented worms
			<i>Dero</i>	segmented worms
			<i>Pristina</i>	segmented worms
		Tubificidae	<i>Aulodrilus</i>	segmented worms
			<i>Limnodrilus</i>	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 (<i>Ichthyomyzon gagei</i>)	X ^{1,2,3}	X ^{4,5}	X ^{4,5}	X ^{1,3,4}	X
ACIPENSERIDAE					
Gulf sturgeon (<i>Acipenser oxyrhynchus desotoi</i>)	X ^{2,3}	--	--	--	--
POLYODONTIDAE					
Paddlefish (<i>Polyodon spathula</i>)	X ¹²			X ¹²	
LEPISOSTEIDAE					
Spotted gar (<i>Lepisosteus osseus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Longnose gar (<i>Lepisosteus osseus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
AMIIDAE					
Bowfin (<i>Amia calva</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
ANGUILLIDAE					
American eel (<i>Anguilla rostrata</i>)	X ^{1,2}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
CLUPEIDAE					
Alabama shad (<i>Alosa alabamae</i>)	X ^{1,2,3}	X ^{1,3,4}	X ^{1,3,4}	X ³	X ³
Skipjack herring (<i>Alosa chrysochloris</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ³	X ³
Gizzard shad (<i>Dorosoma cepedianum</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Threadfin shad (<i>Dorosoma petenense</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
SALMONIDAE⁶					
Brook trout (<i>Salvelinus fontinalis</i>)	--	--	X ^{1,2,4}	--	--
Brown trout (<i>Salmo trutta</i>)	--	--	X ^{1,2,4}	--	--
Rainbow trout (<i>Oncorhynchus mykiss</i>)	--	--	X ^{1,2,4}	--	--
CYPRINIDAE					
Bluefin stoneroller (<i>Campostoma pauciradii</i>)	--	X ^{1,4}	X ^{1,4}	X ^{1,4}	X ^{1,4}
Goldfish (<i>Carassius auratus</i>)	--	X ^{1,4,5}	X ^{1,4,5}	--	--
Grass carp (<i>Ctenopharyngodon idella</i>)	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 (<i>Cyprinella⁷ callitaenia</i>)	X ^{1,2}	X ^{1,4,8}	X ^{1,4,5}	X ^{1,4}	X ^{1,4}
Bannerfin shiner (<i>Cyprinella⁷ leedsii</i>)	X ³	--	--	--	--
Red shiner (<i>Cyprinella⁷ lutrensis</i>)	--	--	X	--	--
Blacktail shiner (<i>Cyprinella⁷ venusta</i>)	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 (<i>Cyprinus carpio</i>)	X ^{1,2}	X ^{1,4,5}	X ^{1,4,5}	X	--
Silverjaw minnow (<i>Notropis buccatus</i>)	X ^{1,2}	X ^{1,4,5,8}	X ^{1,4,5,8}	--	X ^{1,4}
Clear chub (<i>Hybopsis winchelli</i>)	X ^{1,2,3}	X ^{1,3,5}	X ^{1,3,5}	X ^{1,3}	X ^{1,3}
Bandfin shiner (<i>Luxilus⁷ zonistius</i>)	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 (<i>Lythrurus⁷ atrapiculus</i>)	--	X ^{1,3}	X ^{1,3}	--	--
Bluehead chub (<i>Nocomis leptoccephalus</i>)	--	X ^{3,4,5}	X ^{3,4,5}	--	X ³
Golden shiner (<i>Notemigonus crysoleucas</i>)	X ³	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{3,4}	X ^{3,4}
Rough shiner (<i>Notropis baileyi</i>)	--	X ^{1,3,4,5}	X ^{1,3,4,5}	--	--
Ironcolor shiner (<i>Notropis chalybaeus</i>)	X ^{1,2,3}	X ²	--	X ^{1,4}	--
Dusky shiner (<i>Notropis cummingsae</i>)	X ^{1,2,3}	X ^{1,4,5}	X ^{1,4,5}	--	--
Redeye chub (<i>Notropis harperi</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4,5}	--
Spottail shiner (<i>Notropis hudsonius</i>)	--	X ^{1,3,4}	X ^{1,3,4}	--	--
Highscale shiner (<i>Notropis hypsilepis</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Longnose shiner (<i>Notropis longirostris</i>)	X ^{1,2}	X ^{1,4,5}	X ^{1,4,5}	X ^{1,4}	X ^{1,4}
Yellowfin shiner (<i>Notropis lutipinnis</i>)	--	--	X ^{1,4,8}	--	--
Taillight shiner (<i>Notropis maculatus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Coastal shiner (<i>Notropis petersoni</i>)	X ^{1,2,3}	X ⁸	X ⁸	X ^{1,3,4}	--
Weed shiner (<i>Notropis texanus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4,5}	--
Coosa shiner (<i>Notropis xaenocephalus</i>)	--	--	X ^{1,4,8}	--	--
Pugnose minnow (<i>Opsopoeodus emiliae</i>)	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 (<i>Pimephales promelas</i>)	--	--	X	X ³	X ³
Broadstripe shiner (<i>Pteronotropis⁷ euryzonus</i>)	--	X ^{1,3,4,5}	--	X ³	--
Sailfin shiner (<i>Pteronotropis⁷ hypselopterus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{2,4,5}	--
Flagfin shiner (<i>Pteronotropis⁷ signipinnis</i>)	X ^{1,2,3}	X	--	--	--
Bluenose shiner (<i>Pteronotropis⁷ welaka</i>)	X ^{1,3,5}	X ^{1,3,5}	--	X ^{1,3}	--
Creek chub (<i>Semotilus atromaculatus</i>)	X ^{1,2,3}	--	X ^{1,3,4,5,8}	--	X ^{1,3,4,5,8}
Dixie chub (<i>Semotilus thoreauianus</i>)	--	--	X	--	--
CATASTOMIDAE					
Quillback (<i>Carpionodes cyprinus</i>)	X ^{1,2,3,4}	X ^{1,3,4,5}	--	X ³	--
White sucker (<i>Catostomus commersonii</i>)	--	--	X	--	--
Creek chubsucker (<i>Erimyzon oblongus</i>)	X ²	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Lake chubsucker (<i>Erimyzon sucetta</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4,5}	--
Alabama hog sucker (<i>Hypentelium etowanum</i>)	--	X ^{1,4,5,8}	X ^{1,4,5,8}	--	--
Spotted sucker (<i>Minytrema melanops</i>)	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 redbhorse (<i>Moxostoma sp. cf. poecilurum</i>)	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 (<i>Scartomyzon⁹ lachneri</i>)	--	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Striped jumprock (<i>Scartomyzon⁹ rupiscartes</i>)	--	--	X ^{1,4,8}	--	X ³
ICTALURIDAE					
Snail bullhead (<i>Ameiurus¹⁰ brunneus</i>)	X	X	X	X	X
White catfish (<i>Ameiurus¹⁰ catus</i>)	X	X	--	X	--
Black bullhead (<i>Ameiurus¹⁰ melas</i>)	--	--	X	--	--
Yellow bullhead (<i>Ameiurus¹⁰ natalis</i>)`	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Brown bullhead (<i>Ameiurus¹⁰ nebulosus</i>)	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 (<i>Ameiurus¹⁰ serracanthus</i>)	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 (<i>Ictalurus punctatus</i>)	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 (<i>Noturus gyrinus</i>)	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 (<i>Noturus funebris</i>)	X ^{1,2,3}	--	--	--	--	
Speckled madtom (<i>Noturus leptacanthus</i>)	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 (<i>Pylodictis olivaris</i>)	X ²	X _{3,4,8}	X _{3,4,8}	X ^{1,3,4}	X ^{1,3,4}	
ESOCIDAE						
Redfin pickerel (<i>Esox americanus</i>)	X ^{1,2,3}	X _{1,3,4,5}	X _{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}	
Chain pickerel (<i>Esox niger</i>)	X ^{1,2,3}	X _{1,3,4,5}	X _{1,3,4}	X ^{1,3,4}	X ^{1,3,4}	
APHREDODERIDAE						
Pirate perch (<i>Aphredoderus sayanus</i>)	X ^{1,2,3}	X _{1,3,4,5}	X _{1,3,4,5}	X ^{1,3,4}	--	
BELONIDAE						
Atlantic needlefish (<i>Strongylura marina</i>)	X ^{1,2}	X _{1,4,5}	--	--	--	
FUNDULIDAE						
Golden topminnow (<i>Fundulus chrysotus</i>)	X ^{1,3,4}	--	--	X ^{1,3,4}	--	
Banded topminnow (<i>Fundulus cingulatus</i>) ¹¹	X ^{1,2,3}	--	--	--	--	
Eastern starhead (<i>Fundulus escambiae</i>)	X	--	--	X	--	
Blackspotted topminnow (<i>Fundulus olivaceus</i>)	X ²	X _{1,3,4,5,8}	X _{1,3,4,5,8}	--	--	
Southern studfish (<i>Fundulus stellifer</i>)	--	X _{1,3,4,8}	X _{1,3,4,8}	--	--	
Pygmy killifish (<i>Leptolucania ommata</i>)	X ^{1,2,3}	--	--	--	--	
Bluefin killifish (<i>Lucania goodie</i>)	X ^{1,2,3}	--	--	--	--	
POECILIIDAE						
Mosquitofish <i>Gambusia</i> sp. cf. <i>affinis</i>)	X ^{1,2,3}	X _{1,3,4,5}	X _{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}	
Least killifish (<i>Heterandria formosa</i>)	X ^{1,2,3}	X _{1,3}	--	X ^{1,3}	--	
Sailfin molly (<i>Poecilia latipinna</i>)	X ³	--	--	--	--	
ATHERINIDAE						
Brook silverside (<i>Labidesthes sicculus</i>)	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 (<i>Cottus bairdi</i>)	--	--	X ^{1,3,4,8}	--	--
Banded sculpin (<i>Cottus carolinae</i>)	--	--	X ^{1,3,4,8}	--	--
MORONIDAE					
White bass (<i>Morone chrysops</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Striped bass (<i>Morone saxatilis</i>)	X ^{1,2,3}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}
Sunshine bass (<i>Morone chrysops X saxatilis</i>)	X ³	X ³	X ³	X ³	X ³
ELASSOMATIDAE					
Everglades pygmy sun fish (<i>Elassoma everglade</i>)	X ^{1,2,3}	--	--	X ^{1,3,4}	--
Okefenokee pygmy sun fish (<i>Elassoma okefenokee</i>)	X ^{1,2,3}	--	--	--	--
Banded pygmy sunfish (<i>Elassoma zonatum</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
CENTRARCHIDAE					
Shadow bass (<i>Ambloplites ariommus</i>)	X ²	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}
Flier (<i>Centrarchus macropterus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	--
Bluespotted sunfish (<i>Enneacanthus obesus</i>)	X ^{1,2,3}	--	--	X ^{1,2,3}	--
Banded sunfish (<i>Enneacanthus auritus</i>)	X ^{1,2,3}	--	--	X ^{1,3,4}	--
Redbreast sunfish (<i>Lepomis auritus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Green sunfish (<i>Lepomis cyanellus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ³	X ³
Warmouth (<i>Lepomis gulosus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Orangespotted sunfish (<i>Lepomis humilis</i>)	X ^{1,2,3}	X ^{1,4,5}	--	X ³	--
Bluegill (<i>Lepomis macrochirus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Dollar sunfish (<i>Lepomis marginatus</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Longear sunfish (<i>Lepomis megalotis</i>)	X ³	X ^{1,3,4,5}	X ^{1,3,4,5}	--	--
Redear sunfish (<i>Lepomis microlophus</i>)	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 (<i>Lepomis miniatus X L. punctatus</i>)	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 (<i>Micropterus coosae</i>)	--	X ^{1,3,4,5,8}	X ^{1,3,4,5,8}	X ^{1,3,4}	X ^{1,3,4}
Shoal bass (<i>Micropterus cataractae</i>)	X ^{1,2,3}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}
Smallmouth bass (<i>Micropterus dolomieu</i>)	--	X ^{1,3,4,5}	X ^{1,3,4,5}	--	--
Largemouth bass (<i>Micropterus salmoides</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
White crappie (<i>Pomoxis annularis</i>)	X ³	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}	X ^{1,3,4}
Black crappie (<i>Pomoxis nigromaculatus</i>)	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 (<i>Ammocrypta bifascia</i>)	X ^{1,2,3}	--	--	--	--
Brown darter (<i>Etheostoma edwini</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Swamp darter (<i>Etheostoma fusiforme</i>)	X ^{1,2,3}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Goldstripe darter (<i>Etheostoma parvipinne</i>)	X ^{2,3,4}	X ^{1,3,4,5}	--	X ^{1,3,4}	--
Gulf darter (<i>Etheostoma swaini</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Yellow perch (<i>Perca flavescens</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ³	X ³
Blackbanded darter (<i>Percina nigrofasciata</i>)	X ^{1,2,3}	X ^{1,3,4,5}	X ^{1,3,4,5}	X ^{1,3,4}	X ^{1,3,4}
Sauger (<i>Sander canadensis</i>)	X ^{1,2,3}	X ^{1,3,4}	X ^{1,3,4}	--	--
Walleye (<i>Sander vitreum</i>)	--	X ^{1,3,4}	X ^{1,3,4}	--	--
MUGILIDAE					
Mountain mullet (<i>Agonostomus monticola</i>)	X ^{1,2,3}	--	--	--	--
Striped mullet (<i>Mugil cephalus</i>)	X ²	--	--	--	--
White mullet (<i>Mugil curema</i>)	X ^{1,2,3}	--	--	X ³	--
SOLEIDAE					
Hogchoker (<i>Trinectes maculatus</i>)	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 2009c; 13. From Maceina et al. 1999.

**Table H-6.
Partial list of phytoplankton species documented in Apalachicola Bay (Livingston 1984)**

<i>Actinocyclus ehrenbergii</i>	<i>Chaetoceros lorenzianus</i>	<i>Grammatophora marina</i>	<i>Pinnularia</i> spp.
<i>Actinocyclus normanii f. subsala</i>	<i>Chaetoceros pelagicus</i>	<i>Guirardia flaccida</i>	<i>Pleurosigma</i> spp.
<i>Actinoptychus undulatus</i>	<i>Chaetoceros peruvianus</i>	<i>Gyrosigma</i> spp.	<i>Proboscia alata</i>
<i>Asterionella formosa</i>	<i>Chaetoceros</i> spp.	<i>Hemiaulus hauckii</i>	<i>Protoperidinium grande</i>
<i>Aulacoseira granulata</i>	<i>Cocconeis disculoides</i>	<i>Licmophora abbreviata</i>	<i>Rhabdonema adriaticum</i>
<i>Bacteriastrum delicatulum</i>	<i>Coscinodiscus apiculatus</i>	<i>Lithodesmium undulatum</i>	<i>Rhizosolenia bergonii</i>
<i>Bacteriastrum elongatum</i>	<i>Coscinodiscus centralis</i>	<i>Melosira dubia</i>	<i>Rhizosolenia calcar-avis</i>
<i>Bellerochea malleus</i>	<i>Coscinodiscus concinnus</i>	<i>Melosira nummuloides</i>	<i>Rhizosolenia hebetata</i>
<i>Biddulphia alternans</i>	<i>Coscinodiscus excentricus</i>	<i>Melosira sulcata</i>	<i>Rhizosolenia imbricata</i>
<i>Ceratium concilians</i>	<i>Coscinodiscus marginatus</i>	<i>Melosira varians</i>	<i>Rhizosolenia robusta</i>
<i>Ceratium furca</i>	<i>Coscinodiscus nitidus</i>	<i>Navicula lyra</i>	<i>Rhizosolenia setigera</i>
<i>Ceratium fuses</i>	<i>Coscinodiscus oculus-iridis</i>	<i>Navicula</i> spp.	<i>Rhizosolenia</i> spp.
<i>Ceratium massiliense</i>	<i>Coscinodiscus</i> spp.	<i>Nitzschia closterium</i>	<i>Rhizosolenia stolterfothii</i>
<i>Ceratium trichoceros</i>	<i>Coscinodiscus wailessii</i>	<i>Nitzschia paradoxa</i>	<i>Scenedesmus quadricauda</i>
<i>Ceratium tripos</i>	<i>Cymatosira belgica</i>	<i>Nitzschia pungens</i>	<i>Skeletonema costatum</i>
<i>Chaetoceros affinis</i>	<i>Cymbella tumida</i>	<i>Nitzschia sigmoidea</i>	<i>Surirella fastuosa</i>
<i>Chaetoceros brevis</i>	<i>Detonula pumila</i>	<i>Nitzschia</i> spp.	<i>Synedra</i> spp.
<i>Chaetoceros coarctatus</i>	<i>Diatoma</i> spp.	<i>Odontella aurita</i>	<i>Thalassionema nitzschioides</i>
<i>Chaetoceros compressus</i>	<i>Dinophysis caudate</i>	<i>Odontella longicuris</i>	<i>Thalassiothrix frauenfeldii</i>
<i>Chaetoceros constrictus</i>	<i>Dinophysis diegensis</i>	<i>Odontella rhombus</i>	<i>Thalassiothrix longissima</i>
<i>Chaetoceros curvisetus</i>	<i>Dinophysis tripos</i>	<i>Odontella sinensis</i>	<i>Thalassiothrix mediterranea</i>
<i>Chaetoceros danicus</i>	<i>Entomoneis paludosa</i>	<i>Pediastrum duplex</i>	<i>Triceratium favus</i>
<i>Chaetoceros decipiens</i>	<i>Eucampia cornuta</i>	<i>Pediastrum simplex</i>	<i>Triceratium reticulum</i>
<i>Chaetoceros didymus</i>	<i>Eupodiscus radiatus</i>	<i>Pediastrum tetras var. tetraodon</i>	
<i>Chaetoceros glandazii</i>	<i>Fragilaria</i> spp.	<i>Peridinium</i> 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		Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened/Endangered	Nonindigenous
			Apalachicola Bay	Estuary						
<i>Acipenser oxyrinchus desotoi</i>	Gulf sturgeon		X	X		X			X	
<i>Adinia xenica</i>	diamond killifish	X								
<i>Agonostomus monticola</i>	mountain mullet					X				
<i>Alosa alabamae</i>	Gulf or Alabama shad					X				
<i>A. chrysochloris</i>	skipjack herring					X				
<i>Aluterus schoepfii</i>	orange filefish			X						
<i>Ameiurus catus</i>	white catfish			X						
<i>Ameiurus natalis</i>	yellow bullhead	X								
<i>Anchoa hepsetus</i>	striped anchovy		X	X	X					
<i>Anchoa mitchilli</i>	bay anchovy	X	X	X	X					
<i>Ancylopsetta ommata</i>	ocellated flounder			X				X		
<i>Anguilla rostrata</i>	american eel	X				X				
<i>Archosargus probatocephalus</i>	sheepshead	X		X				X		
<i>Ariopsis felis</i>	hardhead catfish			X						
<i>Astroscopus y-graecum</i>	southern stargazer			X						
<i>Atherinidae</i>	silversides				X					
<i>Bagre marinus</i>	gafftopsail catfish			X						
<i>Bairdiella chrysoura</i>	silver perch	X	X	X	X					
<i>Brevoortia patronus</i>	Gulf menhaden	X		X	X					
<i>Carangoides bartholomaei</i>	yellow jack			X						
<i>Caranx hippos</i>	crevalle jack			X						
<i>Centropristis striata</i>	black sea bass			X						
<i>Chaetodipterus faber</i>	atlantic spadefish			X						
<i>Chilomycterus schoepfii</i>	striped burrfish			X						
<i>Chloroscombrus chrysurus</i>	atlantic bumper			X	X					
<i>Ctenogobius boleosoma</i>	darter goby			X						
<i>Ctenopharyngodon idella</i>	grass carp									X
<i>Cynoscion arenarius</i>	sand sea trout	X		X	X					
<i>Cynoscion nebulosus</i>	spotted seatrout		X	X	X			X		
<i>Cyprinella callitaenia</i>	bluestripe shiner					X				
<i>Cyprinodon variegatus</i>	sheepshead minnow	X								
<i>Cyprinus carpio</i>	common carp	X								X
<i>Dasyatis sabina</i>	Atlantic stingray			X						
<i>Diplectrum formosum</i>	sand perch			X						

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
<i>Diplodus holbrookii</i>	spottail pinfish			X						
<i>Dorosoma petenense</i>	threadfin shad			X						
<i>Epinephelus sp.</i>	grouper			X				X		
<i>Etropus crossotus</i>	fringed flounder			X				X		
<i>Eucinostomus argenteus</i>	spotfin mojarra			X						
<i>Eucinostomus gula</i>	silver jenny	X	X	X						
<i>Fundulus confluentus</i>	marsh killifish	X								
<i>Fundulus grandis</i>	Gulf killifish	X								
<i>Fundulus similis</i>	longnose killifish	X	X							
<i>Gobiesox strumosus</i>	skilletfish				X					
<i>Gobionellus hastatus</i>	darer goby			X						
<i>Gobiosoma bosc</i>	naked goby	X		X						
<i>Gobiosoma sp.</i>	naked goby				X					
<i>Gymnura micrura</i>	smooth butterfly ray			X						
<i>Harengula jaguana</i>	scaled sardine	X		X	X					
<i>Hippocampus erectus</i>	lined or spotted seahorse			X						
<i>Hypleurochilus geminatus</i>	crested blenny				X					
<i>Hypsoblennius hentz</i>	feather blenny			X	X					
<i>Ictalurus furcatus</i>	blue catfish									X
<i>Lagodon rhomboides</i>	pinfish		X	X	X					
<i>Leiostomus xanthurus</i>	spot		X	X	X					
<i>Lepisosteus osseus</i>	longnose gar	X								
<i>Lepomis cyanellus</i>	green sunfish							X		X
<i>Lepomis humilis</i>	orange-spotted sunfish									X
<i>Lepomis microlophus</i>	redeer sunfish	X						X		
<i>Lepomis punctatus</i>	spotted sunfish	X								
<i>Lobotes surinamensis</i>	tripletail			X				X		
<i>Lolliguncula brevis</i>	atlantic brief squid									
<i>Lucania goodei</i>	bluefin killifish	X								
<i>Lucania parva</i>	rainwater killifish	X	X	X						
<i>Lutjanus griseus</i>	gray snapper	X		X						
<i>Menidia beryllina</i>	inland silverside	X	X	X						
<i>Menticirrhus americanus</i>	southern kingfish			X	X					
<i>Menticirrhus saxatilis</i>	northern kingfish or Gulf minkfish			X						
<i>Microgobius gulosus</i>	clown goby	X		X						
<i>Microgobius thalassinus</i>	green goby			X						

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
<i>Micropogonias undulatus</i>	Atlantic croaker	X		X	X			X		
<i>Micropterus cataractae</i>	shoal bass						X	X		
<i>Micropterus punctulatus</i>	spotted bass							X		X
<i>Micropterus salmoides</i>	largemouth bass	X						X		
<i>Monacanthus ciliatus</i>	fringed filefish			X						
<i>Morone chrysops</i>	white bass							X		X
<i>Morone saxatilis</i>	striped bass					X		X		X
<i>Moxostoma n. sp. cf poecilurum</i>	grayfin redhorse						X			
<i>Mugil cephalus</i>	black, gray, or striped mullet	X	X							
<i>Mugil curema</i>	silver or white mullet	X								
<i>Mugil sp.</i>	gray mullets			X						
<i>Myrophis punctatus</i>	speckled worm eel			X						
<i>Notemigonus crysoleucas</i>	golden shiner	X								
<i>Notropis sp.</i>	eastern shiners	X								
<i>Notropis zonistius</i>	bandfin shiner						X			
<i>Ogilbia cayorum</i>	key brotula			X						
<i>Oligoplites saurus</i>	leatherjack or leatherjacket			X						
<i>Ophichthus gomesii</i>	shrimp eel			X						
<i>Ophidion holbrookii</i>	longnose cusk-eel			X						
<i>Opsanus beta</i>	Gulf toad fish		X	X						
<i>Orthopristis chrysoptera</i>	pigfish		X	X						
<i>Paralichthys albigutta</i>	gulf flounder			X				X		
<i>Paralichthys lethostigma</i>	southern flounder	X		X				X		
<i>Peprilus burti</i>	Gulf butterfish			X						
<i>Peprilus paru</i>	northern harvestfish			X						
<i>Perca flavescens</i>	yellow perch							X		X
<i>Poecilia latipinna</i>	sailfin molly	X								
<i>Polydactylus octonemus</i>	Atlantic threadfin			X						
<i>Polyodon spathula</i>	American paddlefish									X
<i>Pomatomus saltatrix</i>	bluefish			X				X		
<i>Pomoxis annularis</i>	white crappie									X
<i>Pomoxis nigromaculatus</i>	black crappie	X						X		
<i>Poqonias cromis</i>	black drum				X			X		
<i>Porichthys porosissimus</i>	Atlantic midshipman			X						
<i>Prionotus scitulus</i>	leopard searobin			X						
<i>Prionotus sp.</i>	North American searobins				X					

Scientific name	Common Name	East Bay	Apalachicola Bay	Estuary	Ichthyo-plankton	Diadromous	Endemic	Sport/Commercial	Threatened /Endangered	Nonindigenous
<i>Prionotus tribulus</i>	bighead searobin			X						
<i>Pylodictis olivaris</i>	flathead catfish							X		X
<i>Rachycentron canadum</i>	cobia		X	X				X		
<i>Rhinoptera bonasus</i>	cownose ray			X						
<i>Sander canadensis</i>	sauger									X
<i>Sardinella aurita</i>	Spanish sardine or round sardinella			X						
<i>Sciaenops ocellatus</i>	red drum			X	X			X		
<i>Scomberomorus cavalla</i>	king mackerel			X				X		
<i>Scomberomorus maculatus</i>	Atlantic Spanish mackerel			X				X		
<i>Selene vomer</i>	lookdown			X						
<i>Seriola sp.</i>	amberjack			X				X		
<i>Sphoeroides nephelus</i>	southern puffer			X						
<i>Sphyraena borealis</i>	northern sennet			X						
<i>Sphyrna tiburo</i>	bonnethead			X						
<i>Stellifer lanceolatus</i>	star drum	X		X						
<i>Stephanolepis hispida</i>	planehead filefish			X						
<i>Strongylura marina</i>	Atlantic needlefish		X			X				
<i>Symphurus plagiusa</i>	blackcheek tonguefish			X						
<i>Syngnathus floridae</i>	dusky pipefish		X	X						
<i>Syngnathus louisianae</i>	chain pipefish			X	X					
<i>Syngnathus scovelli</i>	Gulf pipefish			X	X					
<i>Synodus foetens</i>	inshore lizardfish		X	X				X		
<i>Trachinotus sp.</i>	pompano			X						
<i>Trinectes maculatus</i>	hogchoker	X		X	X	X				
<i>Urophycis floridana</i>	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
<i>Ablabesmyia</i> sp.	non-biting midge	<i>Macoma balthica</i>	baltic macoma
<i>Abra aequalis</i>	atlantic abra	<i>M. mitchelli</i>	matagorda macoma
<i>Acetes americanus</i>	aviu shrimp	<i>Macrobrachium ohione</i>	ohio river shrimp
<i>Acteocina canaliculata</i>	channeled barrel-bubble	<i>Mactrotoma fragilis</i>	fragile surfclam
<i>Alpheus armillatus</i>	banded snapping shrimp	<i>Magelona polydentata</i>	polychaete
<i>A. formosus</i>	striped snapping shrimp	<i>Magelona</i> sp.	polychaete
<i>A. heterochaelis</i>	bigclaw snapping shrimp	<i>Marphysa sanguinea</i>	polychaete
<i>A. normanni</i>	green snapping shrimp	<i>Martesia smithi</i>	boring clam
<i>Ambidexter symmetricus</i>	night shrimp	<i>Mediomastus ambiseta</i>	polychaete
<i>A. almyra</i>	opossum shrimp	<i>Mediomastus</i> sp.	polychaete
<i>A. bahia</i>	opossum shrimp	<i>Melinna maculata</i>	polychaete
<i>Ampelisca abdita</i>	gammarid amphipod	<i>Melitta appendiculata</i>	gammarid amphipod
<i>A. cristata microdentata</i>	gammarid amphipod	<i>M. elongata</i>	gammarid amphipod
<i>A. vadorum</i>	gammarid amphipod	<i>M. fresnelii</i>	gammarid amphipod
<i>A. verrilli</i>	gammarid amphipod	<i>M. intermedia</i>	gammarid amphipod
<i>Amphiteis floridus</i>	polychaete	<i>M. longisetosa</i>	gammarid amphipod
<i>A. gunneri</i>	polychaete	<i>M. nitida</i>	gammarid amphipod
<i>Amphinome rostrata</i>	polychaete	<i>Melongenella corona</i>	crown conch
<i>Amygdalum papyrium</i>	atlantic papermussel	<i>Menippe mercenaria</i>	Florida stone crab
<i>Anachis avara</i>	greedy dovesnail	<i>Metapenaeus intermedius</i>	middle shrimp
<i>A. brasiliana</i>	incongruous ark	<i>Metoporphaphis calcarata</i>	false arrow crab
<i>A. transversa</i>	transverse ark	<i>Microdeutopus</i> sp.	gammarid amphipod
<i>Ancistrosyllis hartmanae</i>	polychaete	<i>Microtendipes</i> sp.	non-biting midge
<i>Ancistrosyllis</i> sp.	polychaete	<i>Mitrella lunata</i>	lunar dovesnail
<i>Aplysia brasiliana</i>	sooty seahare	<i>Mnemiopsis</i> sp.	comb jelly
<i>Arenicola cristata</i>	polychaete	<i>Mulinia lateralis</i>	dwarf surfclam
<i>Argulus</i> sp.	crustacean	<i>Mytilopsis leucophaeta</i>	dark falsemussel
<i>Aricidea fragilis</i>	polychaete	<i>Nanocladus</i> sp.	non-biting midge
<i>Armases cinereum</i>	squareback marsh crab	<i>Neanthes succinea</i>	polychaete
<i>Baetidae</i>	mayfly	<i>Nemertea</i>	proboscis worms
<i>Batea catharinensis</i>	gammarid amphipod	<i>Neopanope packardii</i>	Florida grassflat crab
<i>Beroe</i> sp.	comb jelly	<i>Nereiphylla fragilis</i>	polychaete
<i>Bezzia</i> sp.	biting midge	<i>Neritina reclinata</i>	olive nerite
<i>Bittium varium</i>	grass cerith	<i>Notomastus hemipodus</i>	polychaete

Scientific name	Common name	Scientific name	Common name
<i>Boonea impressa</i>	impressed odostome	<i>Nudibranchia</i>	mollusk
<i>Brachidontes exustus</i>	scorched mussel	<i>Nymphula sp.</i>	moth
<i>Brachidontes sp.</i>	mollusk	<i>Odostomia laevigata</i>	mollusk
<i>Branchioasychis americana</i>	polychaete	<i>Ogyrides alphaerostris</i>	estuarine longeye shrimp
<i>Bulla striata</i>	striate bubble	<i>Ogyrides limicola</i>	longeye shrimps
<i>Busycotypus spiratus</i>	pearwhelk	<i>Olivella sp.</i>	mollusk
<i>Caenis sp.</i>	mayfly	<i>Onuphidae</i>	polychaete
<i>Callibaetis sp.</i>	mayfly	<i>Ophiodromus obscurus</i>	polychaete
<i>Callinectes sapidus</i>	blue crab	<i>Ophiothrix angulata</i>	angular brittle star
<i>Cantharus cancellarius</i>	mollusk	<i>Orchestia grillus</i>	gammarid amphipod
<i>Capitella capitata</i>	polychaete	<i>O. uhleri</i>	gammarid amphipod
<i>Capitellides jonesi</i>	polychaete	<i>Orthocladus sp.</i>	non-biting midge
<i>Carazziella hobsonae</i>	polychaete	<i>Ostrea equestris</i>	crested oyster
<i>Carinobatea sp.</i>	gammarid amphipod	<i>Ostracoda</i>	ostracod
<i>Cassidinidea ovalis</i>	isopod	<i>Ovalipes quadulpensis</i>	lady crab
<i>Cerapus sp. (cf. tubularis)</i>	gammarid amphipod	<i>Pagurus bonairensis</i>	right-handed hermit crabs
<i>Chaetozone sp.</i>	polychaete	<i>P. longicarpus</i>	long-armed hermit crab
<i>Chironomus sp.</i>	non-biting midge	<i>P. pollicaris</i>	flatclaw hermit
<i>Chiton tuberculatus</i>	West Indian green chiton	<i>Palaemon floridanus</i>	Florida grass shrimp
<i>Chrysaora quinquecirrha</i>	sea nettle	<i>Palaemonetes intermedius</i>	brackish grass shrimp
<i>Cladotanytarsus sp.</i>	non-biting midge	<i>P. pugio</i>	daggerblade grass shrimp
<i>Clibanarius vittatus</i>	thinstripe hermit	<i>Palaemonetes spp.</i>	shrimp
<i>Clinotanypus sp.</i>	non-biting midge	<i>P. vulgaris</i>	marsh grass shrimp/ common grass shrimp
<i>Clymenella sp.</i>	polychaete	<i>Panopeus herbstii</i>	atlantic mud crab
<i>Coelotanypus sp.</i>	non-biting midge	<i>Paracaprella tenuis</i>	skeleton shrimp
<i>Corixidae</i>	water boatman	<i>Parachironomus sp.</i>	non-biting midge
<i>Corophium louisianum</i>	gammarid amphipod	<i>Paranais litoralis</i>	oligochaete
<i>C. simile</i>	gammarid amphipod	<i>Paranaitis speciosa</i>	polychaete
<i>Corophium sp.</i>	gammarid amphipod	<i>Parandalia americana</i>	polychaete
<i>Crangonyx richmondensis</i>	bog crangonyctid	<i>P. tricuspis</i>	polychaete
<i>Crassostrea virginica</i>	eastern oyster	<i>Paraonis sp.</i>	polychaete
<i>Crepidula fornicata</i>	atlantic slippersnail	<i>Paraprionospio pinnata</i>	polychaete
<i>C. plana</i>	eastern white slippersnail	<i>Pectinaria gouldi</i>	polychaete
<i>Crepidula sp.</i>	slippersnail	<i>Peloscolex benedeni</i>	oligochaete
<i>Cryptochironomus fulvus</i>	non-biting midge	<i>P. heterochaetus</i>	oligochaete
<i>Cryptochironomus sp.</i>	non-biting midge	<i>Pentacta sp.</i>	pigmy sea cucumber

Scientific name	Common name	Scientific name	Common name
<i>Cumacea sp.</i>	crustacean	<i>Periclimenes americanus</i>	American grass shrimp
<i>Cyathura polita</i>	isopod	<i>P. longicaudatus</i>	longtail grass shrimp
<i>Cyclaspis varians</i>	crustacean	<i>Persephona mediterranea</i>	mottled purse crab
<i>Cymadusa compta</i>	amphipod	<i>Petrolisthes armatus</i>	green porcelain crab
<i>Cymadusa sp.</i>	amphipod	<i>Phallodrilus sp.</i>	oligochaete
<i>Dicrotendipes sp.</i>	non-biting midge	<i>Pionosyllis sp.</i>	polychaete
<i>Dinocardium robustum</i>	mollusk	<i>Podarke sp.</i>	polychaete
<i>Diopatra cuprea</i>	polychaete	<i>Podarkeopsis brevipalpa</i>	polychaete
<i>Diplodonta semiaspera</i>	pimpled diplodon	<i>Podocheila riisei</i>	longfinger neck crab
<i>Dipolydora socialis</i>	polychaete	<i>Polinices duplicatus</i>	mollusk
<i>Dyspanopeus texanus</i>	Gulf grassflat crab	<i>Polydora ligni</i>	polychaete
<i>Echinarachnius parma</i>	sand dollar	<i>P. socialis</i>	polychaete
<i>Echinaster sp.</i>	starfish	<i>P. websteri</i>	polychaete
<i>Edotia montosa</i>	isopod	<i>Polymesoda caroliniana</i>	Carolina marshclam
<i>Edotia sp. (cf. montosa)</i>	isopod	<i>Polypedilum sp.</i>	non-biting midge
<i>Ensis minor</i>	minor jackknife clam	<i>Portunus gibbesii</i>	iridescent swimming crab
<i>Epitonium rupicola</i>	brown-band wentletrap	<i>Procambarus paeninsulanus</i>	crayfish
<i>Erichsonella sp. (cf. filiformis)</i>	isopod	<i>Processa fimbriata</i>	grass night shrimp
<i>Erichthonius sp.</i>	gammarid amphipod	<i>P. hemphilli</i>	night shrimp
<i>E. brasiliensis</i>	gammarid amphipod	<i>Processa sp.</i>	night shrimp
<i>Eteone heteropoda</i>	polychaete	<i>Procladius sp.</i>	non-biting midge
<i>Eupleura sulcidentata</i>	sharp-rib drill	<i>Prunum apicinum</i>	common atlantic marginella
<i>Eurypanopeus depressus</i>	flatback mud crab	<i>Pseudocyrena floridana</i>	Florida marsh clam
<i>Fabricia sp.</i>	polychaete	<i>Rangia cuneata</i>	Atlantic rangia
<i>Farfantepenaeus aztecus</i>	brown shrimp	<i>Rhithropanopeus harrislui</i>	estuarine mud crab
<i>F. duorarum</i>	pink shrimp/northern pink shrimp	<i>Scolecipis texana</i>	polychaete
<i>Fasciolaria tulipa</i>	true tulip	<i>Scoloplos rubra</i>	polychaete
<i>Gammarus lecroyae</i>	gammarid amphipod	<i>Sicyonia brevirostris</i>	hardback shrimp
<i>G. mucronatus</i>	gammarid amphipod	<i>S. dorsalis</i>	lesser rock shrimp
<i>Gammarus sp.</i>	gammarid amphipod	<i>Sigambra bassi</i>	polychaete
<i>Gilvossius setimanus</i>	ghost shrimps	<i>Sphaeroma terebrans</i>	mangrove boring isopod
<i>Gitanopsis spp.</i>	gammarid amphipod	<i>Spiophanes bombyx</i>	polychaete
<i>Glycera americana</i>	polychaete	<i>Squilla empusa</i>	squillid mantis shrimps
<i>Glycinde solitaria</i>	polychaete	<i>Stenonereis martini</i>	polychaete
<i>Glyptotendipes sp.</i>	non-biting midge	<i>Stomolophus meleagris</i>	cabbagehead jellyfish
<i>Grandidierella bonnieroides</i>	gammarid amphipod	<i>Stramonita haemastoma</i>	Florida rocksnail

Scientific name	Common name	Scientific name	Common name
<i>Grandidierella sp.</i>	gammarid amphipod	<i>Streblospio benedicti</i>	polychaete
<i>Haploscoloplos foliosus</i>	polychaete	<i>Syllides sp.</i>	polychaete
<i>H. fragilis</i>	polychaete	<i>Tagelus plebeius</i>	stout tagelus
<i>Hargeria rapax</i>	crustacean	<i>Tanypus sp.</i>	non-biting midge
<i>Harnischia sp.</i>	non-biting midge	<i>Tanytarsus sp.</i>	non-biting midge
<i>Haustoriidae</i>	gammarid amphipod	<i>Taphromysis bowmani</i>	opossum shrimp
<i>Hemipholis elongata</i>	brittle star	<i>T. louisianae</i>	opossum shrimp
<i>Heteromastus filiformis</i>	polychaete	<i>Tellina texana</i>	Texas tellin
<i>Hexapanopeus angustifrons</i>	smooth mud crab	<i>Texadina sphinctostoma</i>	narrowmouth hydrobe
<i>Hippolyte zostericola</i>	zostera shrimp	<i>Thais haemastoma</i>	southern oyster drill
<i>Ischadium recurvum</i>	hooked mussel	<i>Thor dobkini</i>	squat grass shrimp
<i>Kalliapseudes sp.</i>	crustacean	<i>Tozeuma carolinense</i>	arrow shrimp
<i>Laeonereis culveri</i>	polychaete	<i>Trachypenaeus constrictus</i>	roughneck shrimp
<i>Leander tenuicornis</i>	brown grass shrimp	<i>T. similis</i>	roughback shrimp
<i>Lembos sp.</i>	gammarid amphipod	<i>Tubificoides sp.</i>	oligochaete
<i>Lepidactylus sp.</i>	gammarid amphipod	<i>Tubulanus sp.</i>	proboscis worm
<i>Lepidophthalmus jamaicense</i>	ghost shrimps	<i>Uca minax</i>	redjointed fiddler
<i>Libinia dubia</i>	longnose spider crab	<i>Uromunna reynoldsi</i>	isopod
<i>L. emarginata</i>	portly spider crab	<i>Urosalpinx perrugata</i>	Gulf oyster drill
<i>Limnodriloides sp.</i>	oligochaete	<i>Xenanthura brevitelson</i>	isopod
<i>Litopenaeus setiferus</i>	northern white shrimp	<i>Xiphopenaeus kroyeri</i>	Atlantic seabob
<i>Littoridina sp.</i>	mollusk		
<i>Lolliguncula brevis</i>	Atlantic brief squid		
<i>Luidia clathrata</i>	lined sea star		
<i>Lumbrineris tenuis</i>	polychaete		
<i>Lysmata wurdemanni</i>	peppermint shrimp		

References

- Barkuloo, J.M., L. Patrick, L. Stith, and W.J. Troxel. 1987. *National Resource Inventory: Apalachicola-Chattahoochee-Flint River Basin*. U.S. Fish and Wildlife Service, Panama City, Florida.
- Dahlberg, M.D., and D.C. Scott, 1971. The freshwater fishes of Georgia. *Bulletin of the Georgia Academy of Science* 29:1–64.
- Edmiston, H.L., and H.A. Tuck. 1987. *Resource inventory of the Apalachicola River and Bay drainage basin: Tallahassee, Florida*. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.
- Edmiston, H.L. 2008. *A River Meets the Bay: A Characterization of the Apalachicola River and Bay System*. Apalachicola National Estuarine Research Reserve, Apalachicola, Florida.
- Gilbert, R.J. 1969. The distribution of fishes in the central Chattahoochee River drainage. Master's thesis, Auburn University, Auburn, Alabama.
- Gilbert, C.R., R.C. Cashner, and E.O. Wiley. 1992. Taxonomic and nomenclatural status of the banded topminnow, *Fundulus cingulatus*. *Copeia* 1992(3):747–759.
- Jenkins, R.E., and N.M. Burkhead. 1993. *Freshwater Fishes of Virginia*. American Fisheries Society, Bethesda, Maryland.
- Livingston, R.J. 1984. The Ecology of the Apalachicola Bay System: An Estuarine Profile. FWS/OBS82-05. U.S. Fish and Wildlife Service, Washington, D.C.
- Lundberg, J.G. 1992. The phylogeny of ictalurid catfishes a synthesis of recent work. In *Systematics, Historical Ecology, and North American Freshwater Fishes*, ed. R.L. Mayden, pp. 392–420, Stanford University Press, Palo Alto, California.
- Maceina, M. J., J.W. Slipke, and J.M. Grizzle. 1999. Effectiveness of three barrier types for confining grass carp in embayments of Lake Seminole, Georgia. *North American Journal of Fisheries Management* 19:968–976.
- Mayden, R.L. 1989. *Phylogenetic studies of North American minnows with emphasis on the genus Cyprinella* (Teleostei: Cypriniforms). University of Kansas, Natural History Miscellaneous Publication 80, 38 pp.
- Page L.M., and C.E. Johnston. 1990. The breeding behavior of *Opsopoedus emiliae* (Cyprinidae) and its phylogenetic implications. *Copeia*, v.1990: 1,176–1,180.
- Satterfield, J.D. 1961. A study of the distribution of fishes in the headwaters of streams in northern Georgia. Master's Thesis, University of Georgia, Athens, Georgia. USGS (U.S. Geological Survey). 2003. *A GAP Analysis of Georgia. Final Report to the U.S. Geological Survey*. Natural Resources Spatial Analysis Laboratory, University of Georgia, Athens, Georgia.
- USEPA (U.S. Environmental Protection Agency). 2006. *Wadeable Streams Assessment. A Collaborative Survey of the Nation's Streams*. EPA 841-B-06-002. U.S. Environmental Protection Agency, Offices of Research and Development and Water, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 2009b. Draft National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.
- USGS (U.S. Geological Survey). 2009c. Nonindigenous Aquatic Species Database. U.S. Geological Survey, Gainesville, FL. <<http://nas.er.usgs.gov>>. Accessed Dec. 8, 2010.

Yerger, R. 1977. Fishes of the Apalachicola River. In *Proceedings of the Conference on the Apalachicola Drainage System*, eds. R.J. Livingston and E.A. Joyce, Jr., Publication 26, pp. 22-23, Florida Marine Research Institute, St. Petersburg, Florida.

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Appendix I

2

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
- Other (Not Necessary)

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