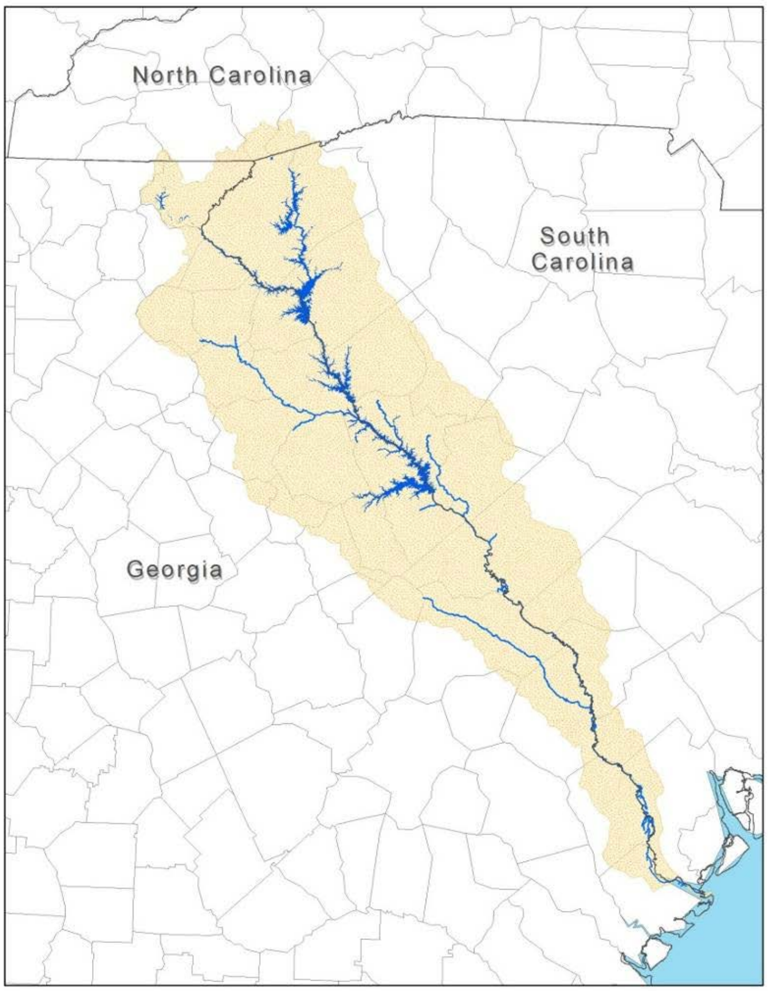
FINAL
ENVIRONMENTAL ASSESSMENT

NEW OPERATING AGREEMENT
BETWEEN U.S. ARMY CORPS OF ENGINEERS, SOUTHEASTERN POWER ADMINISTRATION, AND DUKE ENERGY CAROLINAS, LLC



US Army Corps of Engineers
Savannah District
October 2014

FINAL ENVIRONMENTAL ASSESSMENT
NEW OPERATING AGREEMENT
BETWEEN U.S. ARMY CORPS OF ENGINEERS, SOUTHEASTERN POWER ADMINISTRATION, AND DUKE ENERGY

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FINDING OF NO SIGNIFICANT IMPACT

Name of Action: New Operating Agreement between the U.S. Army Corps of Engineers, the Southeastern Power Administration, and Duke Energy Carolinas, LLC

1. Description of the Proposed Action

The proposed action (Alternative 3) consists of a new Operating Agreement between the U.S. Army Corps of Engineers, the Southeastern Power Administration, and Duke Energy Carolinas, LLC. Duke Energy would modify the Oconee Nuclear Station to allow operations to continue at Lake Keowee elevations down to 790 feet AMSL. A3 would modify the 1968 Agreement as follows:

- Incorporate additional storage capacity in Duke Energy's Bad Creek Reservoir and USACE's Richard B. Russell Reservoir into the calculations determining the remaining usable storage and weekly water release requirement from Lake Keowee. As a result, A3 equalizes the percentage of combined remaining usable storage capacity at USACE's Hartwell, RBR, and J. Strom Thurmond Reservoirs with the percentage of combined remaining usable storage capacity at Duke Energy's Bad Creek Reservoir and Lakes Jocassee and Keowee.
- Revise the Lake Keowee minimum elevation for calculating usable storage to elevation 790 feet AMSL (enabling a 10-foot drawdown of Lake Keowee).
- Lower the Lake Jocassee minimum reservoir elevation six feet (from 1086 feet AMSL to 1080 feet AMSL) and eliminate the allowance for pumping volume in the weekly water release calculation.
- Incorporate the USACE July 2012 Drought Plan operating protocols.
- Incorporate Duke Energy's Low Inflow Protocol (LIP) which provides rules for how they will operate their reservoirs during droughts, including minimum lake elevations and water use conservation for existing and future water intake owners located on Keowee-Toxaway Project Reservoirs.

A3 includes the following provisions to enhance drought tolerance in the Upper Savannah River Basin:

- Duke Energy will require owners of Large Water Intakes on the Duke Energy Projects to comply with its Low Inflow Protocol.
- USACE will require any owner of a Large Water Intake (i.e., water intake with a maximum capacity greater than or equal to one million gallons per day) who is allocated water from the USACE Projects after the effective date of the new Operating Agreement to implement coordinated water conservation measures when the USACE Drought Plan is in effect (similar to the water conservation measures required by the Low Inflow Protocol for Large Water Intake owners on the Duke Energy Projects).
- USACE and Duke Energy will encourage all water users withdrawing water from their respective reservoirs to conserve water in a coordinated manner when the USACE Drought Plan is in effect.

- USACE and Duke Energy will require (whenever feasible) that all Large Water Intakes used for municipal, industrial and power generation purposes that are constructed, expanded or rebuilt on their projects after the effective date of the new Operating Agreement be capable of operating at their permitted capacities at reservoir elevations as low as the applicable hydroelectric station can operate.
- Duke Energy would provide $438,000 in funding to support the next interim of the USACE Savannah River Basin Comprehensive Study (to evaluate reallocating existing storage or measures that could lead to better water management).
- Duke Energy would provide funding and/or in-kind services to USACE and other public entities to improve public boating access at Hartwell and Thurmond Reservoir facilities to fully mitigate for adverse impacts to recreational access to those reservoirs. Those impacts are presently estimated to be $2,938,000 (FY14 price levels) over a 50-year evaluation period.
- To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor, USACE will discharge 200 cubic feet per second of water above that specified in the 2012 Drought Plan from Thurmond Dam for 11 days each year when the USACE reservoirs are in drought status during the summer months. At that time, Duke Energy will continue to release water from their projects to stay in balance with the USACE reservoirs in accordance with the USACE/SEPA/Duke Energy 2014 Operating Agreement.

Duke Energy would bear the estimated $2 Million cost to modify the Oconee Nuclear Station to enable its operations to continue down to a Lake Keowee elevation of 790 feet AMSL. Duke Energy would provide South Carolina with funds to support their participation in the next interim of the USACE Savannah River Basin Comprehensive Study. Duke Energy would provide funds and/or in-kind services to USACE and other public entities to improve public boating access at the Hartwell and Thurmond Reservoirs. USACE would manage those mitigation actions. USACE would continue to operate under the terms of its 2012 Drought Plan. Both organizations would implement the Low Inflow Protocol which describes how they will work with Large Water Intake owners within their reservoirs to conserve water during droughts.

2. Other Alternatives Considered

Alternatives to the Proposed Action were developed as part of the planning process. The alternatives that were considered include:

a. No Action Alternative: Duke Energy and USACE would operate in accordance with the 1968 Operating Agreement

b. Alternative 1: Duke Energy would modify its Oconee Nuclear Station to allow that facility to meet the flow requirements of the 1968 Agreement (i.e., ONS could operate down to a Lake Keowee elevation of 778 feet AMSL).

c. Alternative 2: Duke Energy would operate the Keowee-Toxaway Project as it has since the mid- to late-1990s during drought conditions.

d. Alternative 4 (evaluates how the Low Inflow Protocol in A3 affect reservoir levels and flow releases from the USACE Projects): Includes all features of A3 (same reservoir usable storage updates) except for the Low Inflow Protocol.

3. Coordination

Savannah District coordinated this action with Federal, State and local agencies and issued a Notice of Availability to solicit comments from the public on the Draft Environmental Assessment. Appendix Y contains the responses to each comment that was received.

4. Conclusions

Based on a review of the information contained in this Environmental Assessment (EA), I have determined that the preferred alternative is the best course of action. I have also determined that this new Operating Agreement with the Southeastern Power Administration and Duke Energy is not a major Federal action within the meaning of Section 102(2)(c) of the National Environmental Policy Act of 1969. Accordingly, the preparation of an Environmental Impact Statement is not required. My determination was made considering the following factors discussed in the EA to which this document is attached:

a. The proposed action would not have significant adverse effects on any threatened or endangered species.

b. The proposed action would not cause any significant long term adverse impacts to wetlands.

c. The proposed action would not have significant adverse impacts on cultural resources.

d. The proposed action would not cause or contribute to violations of SC or GA water quality standards.

e. The proposed action would not adversely impact air quality.

f. The proposed mitigation would fully compensate for adverse impacts to recreational users of the Federal reservoirs.

g. The proposed action would not significantly affect hydropower generation at the USACE dams on the Savannah River, or the distribution or sale of that hydropower by SEPA.

h. The proposed action would not result in unacceptable adverse cumulative or secondary impacts.

i. The proposed action complies with Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.”

5. Findings

The proposed action to enter into a new Operating Agreement with the Southeastern Power Administration and Duke Energy for the Savannah River Basin as described in Alternative 3 would result in no significant environmental impacts and is the alternative that represents sound natural resource management practices and environmental standards.

10 OCT 2014
Date

Thomas J. Tickner
Colonel, US Army
Commanding

EXECUTIVE SUMMARY

Background Information

In 1968, the U.S. Army Corps of Engineers (USACE) and the Southeastern Power Administration (SEPA) entered into an Operating Agreement (1968 Agreement) with Duke Energy Carolinas, LLC's (Duke Energy) predecessor company, Duke Power Company, regarding how water would be managed between Duke Energy's Keowee-Toxaway Hydroelectric Project No. 2503 (Keowee-Toxaway Project) and the downstream USACE reservoirs that existed at that time. The purpose of the 1968 Agreement was to ensure the Keowee-Toxaway Project is operated such that the USACE and SEPA will be able to meet their hydropower generating requirements.

The 1968 Agreement is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell Lake and J. Strom Thurmond (JST) Lake with the percentage of combined remaining usable storage capacity at Duke Energy's Lake Jocassee and Lake Keowee during droughts.

There have been many changes in both the USACE and Duke Energy systems since 1968, but the 1968 Agreement has not been modified. The 1968 Agreement uses a minimum reservoir elevation at Lake Keowee of 778 feet above mean sea level (ft AMSL) (Full Pool Elevation is 800 ft AMSL), as described in the Federal Energy Regulatory Commission (FERC) license for the Keowee-Toxaway Project. During the 1970s, Duke Energy constructed Oconee Nuclear Station (ONS) on the shores of Lake Keowee. ONS relies on water stored in Lake Keowee to support station operations. As a result of the NRC requirements in the 1973 NRC license for the ONS, Duke would cease operation of the ONS facility if/when the Lake Keowee reservoir elevation drops below 793 ft AMSL (with certain other plant conditions). In addition, USACE and Duke Energy have constructed an additional reservoir and pumped storage facilities in the Savannah River Basin that affect operation of the Keowee-Toxaway, Hartwell, and JST Projects.

Those later facilities have not been incorporated into the operating rules between the USACE and Duke systems.

USACE modified its reservoir operations through implementation of a Drought Plan (DP) after the 1986-1989 drought. The original 1989 DP has been revised after subsequent droughts and the USACE is currently operating under the July 2012 DP. Duke Energy's FERC license for the Keowee-Toxaway Project expires in 2016 and future operations at the Keowee-Toxaway Project are expected to be modified with FERC relicensing. As part of their relicensing effort, Duke Energy has consulted with a diverse group of stakeholders including water suppliers and non-governmental organizations interested in the Keowee-Toxaway Project's ability to identify ways in which that project could better support future water supply needs in the region and address concerns about the impacts to water supply caused by the extended droughts of record.

As a result of these factors, USACE, SEPA and Duke Energy have worked together to develop a new Operating Agreement that would reflect the modified conditions discussed above. This Environmental Assessment identifies and evaluates the expected effects of a New Operating Agreement (NOA). USACE coordinated a draft of this document with the natural resource agencies and the public to obtain their comments, as required by the National Environmental Policy Act (NEPA). This document also serves as the NEPA analysis for the SEPA, who would also be a signatory to the NOA.

This EA evaluates potential environmental, engineering, and economic impacts associated with five alternatives as described on the following pages.

Alternatives Considered

No Action Alternative (NAA)

The No Action Alternative (NAA) represents operating in accordance with the 1968 Agreement. The 1968 Agreement is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell Lake and JST Lake with the percentage of combined remaining usable storage capacity at Duke Energy's Lake Jocassee and Lake Keowee during droughts. Since the USACE's Richard B. Russell (RBR) Project and Duke Energy's Bad Creek Project were not constructed at the time of the 1968 Agreement, they are not included in the operating rules for determining flow release requirements from Lake Keowee under this alternative. The NAA assumes Duke Energy would draw down the Lake Keowee reservoir elevation below 793 ft AMSL when required. Such an action would require Duke to temporarily cease nuclear generation operations at the ONS, as specified in their license for that facility from the Nuclear Regulatory Commission. The NAA incorporates the most recent version (July 2012) of the USACE's DP operating protocols.

Alternative 1 (A1)

In Alternative 1, Duke Energy would modify the ONS to allow that facility to meet the flow requirements of the 1968 Agreement (i.e., ONS could continue to operate down to a Lake Keowee elevation of 778 ft AMSL). As with the NAA, A1 incorporates the USACE's July 2012 DP operating protocols. A1 is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell Lake and JST Lake with the percentage of combined remaining usable storage capacity at Duke Energy's Lake Jocassee and Lake Keowee. A1 also includes the following provisions to enhance drought tolerance in the Upper Savannah River Basin:

- The USACE will require any owner of a Large Water Intake (i.e., water intake with a maximum capacity greater than or equal to one million gallons per day) who is allocated water from the USACE Projects after the Effective Date of the NOA to implement coordinated water conservation measures when the DP is in effect similar to the water conservation measures required by the LIP for Large Water Intake owners on the Duke Energy Projects. Duke Energy will require owners of Large Water Intakes on the Duke Energy Projects to comply with the LIP.

- The USACE and Duke Energy will encourage all water users withdrawing water from their respective reservoirs to conserve water in a coordinated manner when the DP is in effect similar to the water conservation measures required by the LIP on the Duke Energy Projects.
- The USACE and Duke Energy will require whenever feasible that all Large Water Intakes used for municipal, industrial and power generation purposes that are constructed, expanded or rebuilt on the Duke Energy Projects and the USACE Projects after the Effective Date of the NOA be capable of operating at their permitted capacities at reservoir elevations as low as the applicable hydroelectric station can operate.

Alternative 2 (A2)

Alternative 2 represents the manner in which Duke Energy has operated the Keowee-Toxaway Project since the mid- to late-1990s during extreme drought conditions. For A2, the methodology used to determine required weekly water releases from Lake Keowee is the same as in the NAA. However, no water release would be made from Lake Keowee if that release would result in a Lake Keowee elevation below 794.6 ft AMSL. As with the NAA, A2 incorporates the USACE's July 2012 DP operating protocols. A2 is also based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell Lake and JST Lake with the percentage of combined remaining usable storage capacity at Duke Energy's Lake Jocassee and Lake Keowee, subject to the NRC license requirements for the ONS. A2 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

Alternative 3 (A3)

While the NAA's overall concept of balancing the percentage of combined remaining usable storage between the Duke Energy and USACE Reservoirs is unchanged in Alternative 3, A3 incorporates additional storage facilities, updated storage volumes, coordinated drought response, measures to protect Upper Savannah River Basin water supply, and provisions expected to be included in FERC's 2016 operating license for the Keowee-Toxaway Project. As with the NAA, A3 incorporates the USACE's July 2012 DP operating protocols.

In A3, Duke Energy would modify the ONS to allow normal operations to continue when Lake Keowee elevations drop below the current NRC limitation of 794.6 ft AMSL. The Lake Keowee minimum elevation for calculation of usable storage would be revised to elevation 790 ft AMSL, which allows for a 10-foot drawdown of Lake Keowee during droughts. The Lake Jocassee minimum reservoir elevation would be lowered six feet (from 1086 ft AMSL to 1080 ft AMSL). A3 incorporates additional storage capacity created by the USACE and Duke Energy since the 1968 Agreement was executed with the addition of Bad Creek Reservoir and RBR Lake. These reservoirs increase the total storage volumes in the systems and A3 includes them in the calculation of usable storage and weekly water release requirements from Lake Keowee. Therefore, A3 is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell, RBR, and JST Lakes with the percentage of combined remaining usable storage capacity at Duke Energy's Bad Creek Reservoir and Lakes Jocassee and Keowee. A3 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1. Duke Energy would implement the Keowee-Toxaway Low Inflow Protocol (LIP) which provides rules for how the Duke Energy Reservoirs are operated during periods of drought, including minimum reservoir elevations and water withdrawal reductions for varying levels of drought severity (and closely follows the USACE's July 2012 DP).

Alternative 4 (A4)

Alternative 4 was included to evaluate how LIP operations under A3 affect reservoir levels and flow releases from the USACE Projects. Accordingly, A4 includes the same reservoir usable storage updates as A3, but A4 does not include the Keowee-Toxaway Project LIP provisions contained in A3. As with the NAA, A4 incorporates the USACE's July 2012 DP operating protocols. As with A3, A4 uses the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell, RBR, and JST Lakes with that in Duke

Energy's Bad Creek Reservoir and Lakes Jocassee and Keowee. A4 also includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

Hydrologic Modeling

To identify and evaluate differences between the alternatives, the USACE's Hydrologic Engineering Center's Reservoir System Simulation (HEC-ResSim) hydrologic model was used to simulate reservoir elevations, usable storage, flow releases from, and hydroelectric energy production by all Duke Energy and USACE reservoirs in the Upper Savannah River Basin. HEC-ResSim model results were evaluated for each of the alternatives over a 73-year period of record (POR) (1939–2011). Two of the alternatives (NAA and A1) are the same from a reservoir modeling perspective and did not require separate model simulations, and are referred to as NAA/A1 in the modeling results.

Plan Comparison

During non-drought or wet hydrologic periods, there are only minimal differences in reservoir elevations, flow releases from, and hydroelectric energy production between alternatives. During drier or drought hydrological periods, there are some differences between alternatives. However, these differences are relatively small in magnitude, infrequent, and are not expected to result in significantly adverse environmental or socioeconomic impacts.

Socioeconomic Results

The Strom Thurmond Institute of Government and Public Affairs at Clemson University developed regional economic models for the counties surrounding Duke Energy's Lake Keowee and the USACE's Hartwell and JST Lakes. These models rely on three parameters as indicators of economic movement: recreational use at each reservoir, real estate transactions around each reservoir, and the sale of reservoir-related goods and services (e.g., sporting goods, bars, boating stores, etc.). The models are designed to evaluate regional economic conditions (both positive and negative) associated with every foot of water elevation change in these three reservoirs. The economic model results span 2001–2008, which includes the basin's 2008 drought of record.

For Lake Keowee, during the majority of the period modeled, differences between alternatives are within $2,000 of each other and three jobs over the eight-year study period. The largest differences between alternatives occur near the end of 2008 and are the result of extreme drought conditions. During that period, the NAA and A1 would result in the largest economic impact (a loss of $12,000 and 12 jobs) when Lake Keowee's elevation drops to 782 ft AMSL. A2 would result in the least economic impact (a loss of $4,000 and four jobs) because flow releases are not made if those releases would result in a Lake Keowee reservoir elevation below 794.6 ft AMSL. A3 and A4 are similar to each other and fall between A2 and NAA/A1 results (a loss of $6,000 and six jobs).

For Hartwell and JST Lakes, during the entire period modeled, economic and employment impacts are similar for all alternatives.

<u>Hydropower Generation and ONS Impacts</u>

HEC-ResSim model output identifies hydroelectric generation for each of the Duke Energy and USACE projects. Average annual net hydroelectric energy generation (in both dollars and MWHr) for each alternative over the 73-year POR for the Duke Energy and USACE systems is provided in Table ES-1. For the Duke Energy system, A4 produces the highest average annual net generation at $92.2 million, while NAA/A1, A2, and A3 are slightly lower ranging from $91.1 to $92.1 million. Except for A4, there is no difference in average annual net hydroelectric generation at the USACE Projects between the alternatives. A4 would result in slightly lower average annual net generation than the other alternatives. There is very little difference (<0.5%) in the value of the average annual net generation value between alternatives.

Table ES-1 Average Annual Net Hydroelectric Energy Generation (1939–2011)

Owner	Average Annual Net Hydroelectric Energy Generation[1] $ millions / MWh			
	NAA/A1	A2	A3	A4
Duke Energy[2, 3]	92.1 / (683,000)	91.1 / (635,000)	91.9 / (657,000)	92.2 / (660,000)
USACE	120.4 / 1,478,000	120.4 / 1,478,000	120.4 / 1,478,000	120.4 / 1,477,000
System	212.5 / 795,000	211.5 / 843,000	212.3 / 821,000	212.6 / 817,000

[1] Future water withdrawals with historic hydrology
[2] Average annual net generation for the Duke Energy system excludes generation impacts to ONS
[3] MWh for the Duke Energy system are negative due to pumping operations at Jocassee Pumped Storage Station and the Bad Creek Project.

Under the NAA, Lake Keowee reservoir levels would have fallen below 793 ft AMSL for a 348-day period in 2008-2009. The resulting forced outage at ONS would have resulted in energy replacement costs estimated at $913 million (assuming future water withdrawals and historic hydrology conditions). Costs to upgrade the existing electric transmission system to lessen the severity of grid reliability issues while ONS is off-line are estimated at $232 million. Under that alternative, actions to address those grid reliability issues should begin immediately to avoid those concerns.

A1 includes modification to the ONS station to allow its operation to continue down to a Lake Keowee elevation of 778 feet AMSL. An engineering alternatives study conducted by Enercon in 2011 estimates that capital costs for this design modification would reach at least $800 million, not including additional O&M costs. These costs are quite high when viewed in the context of the infrequent and relatively small benefits that would result.

Both A3 and A4 include modification to the ONS station to allow its operation to continue with Lake Keowee below 794.6 ft AMSL. Current capital cost estimates to modify ONS are up to $2 million. Modification of the ONS in A3 and A4 provides additional usable storage capacity in the Duke Energy system that helps maintain ONS operations (thus preventing expensive energy replacement costs and transmission system upgrade costs) and provides additional storage that can be used to support other water users in the Upper Savannah River Basin. Net USACE hydroelectric generation for A3 and A4 are similar to or greater than the other alternatives.

Pool Elevations

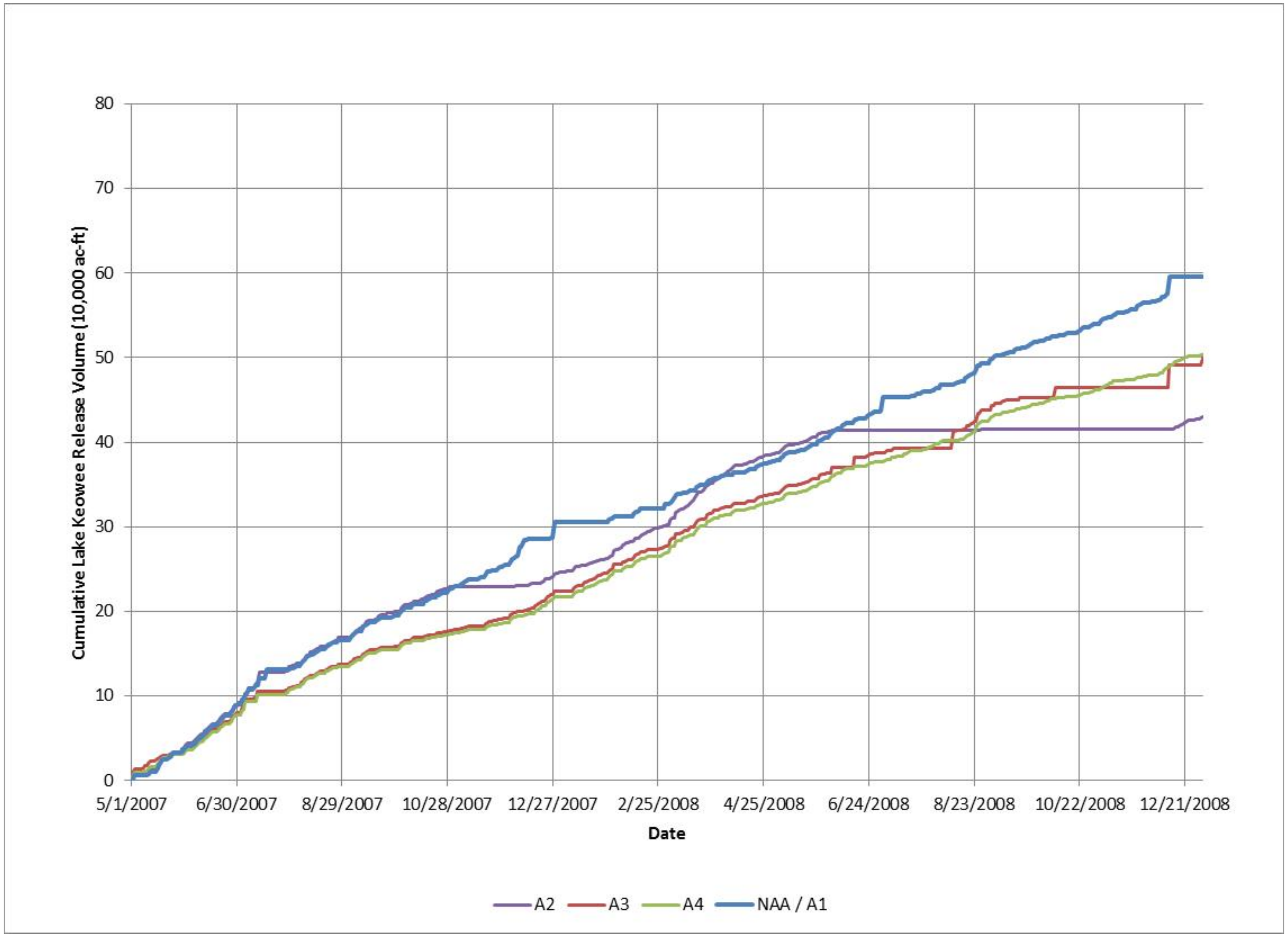
NAA and A1 would produce the lowest reservoir elevations in Duke Energy's Lakes Jocassee and Keowee. For those two lakes, A3 and A4 are almost identical and result in reservoir elevations higher than the NAA/A1, and A2 reservoir elevations for most of the POR (see Table ES-2). The only exceptions are during extreme drought conditions when the HEC-ResSim model logic tries to maintain Lake Keowee reservoir elevations at or above 794.6 ft AMSL in A2 and allows reservoir elevations down to 790 ft AMSL in A3 and A4.

The individual USACE reservoir elevations are similar for each alternative (see Table ES-2). Differences in USACE reservoir elevations occur infrequently and are relatively short in duration.

During drought conditions, A2 would maintain the highest Lake Keowee reservoir elevations. However, this is at the expense of Lake Jocassee, which would experience its lowest reservoir elevations under this alternative. During extreme drought periods, A2 would result in Lake Keowee elevations below 794.6 ft AMSL, which negatively impacts ONS operations. This would occur when Lake Jocassee storage capacity is depleted, making it harder to maintain Lake Keowee reservoir elevations above 794.6 ft AMSL which increases the risk of forced outages at ONS.

Figure ES-1 depicts Lake Keowee cumulative flow releases for each alternative during the 2007-2008 extreme drought. The HEC-ResSim model results presented in this figure assume the USACE implements its Drought Plan as written, reducing discharges from JST when a drought level is triggered. During the deepest part of the extreme drought (third quarter 2008), A3 and A4 flow releases would have been greater than A2 flow releases. This is due to Keowee-Toxaway Project operations continuing to provide generation flow releases to the USACE

Figure ES-1 Cumulative Lake Keowee Volume Released to the USACE System (Future Water Withdrawals with Historic Hydrology)



reservoir system under A3 that are not provided under A2. A2 would greatly reduce, and at times eliminate, flow releases from Keowee into the USACE Reservoirs during extreme droughts. NAA, A1, and A2 would also continue the vulnerability of the ONS to being shut down during extreme droughts.

The $2 million modification to ONS in A3 and A4 provides additional usable storage capacity in the Duke Energy system that can be used to support other water users in the Upper Savannah River Basin, and provides downstream flow releases to the USACE system during the deepest parts of drought periods. During less severe droughts, such as occurred at the end of 2006, A3 and A4 result in slightly lower reservoir elevations for Hartwell and JST Lakes (by approximately 0.7 feet and 0.5 feet, respectively) compared to NAA/A1 reservoir elevations. During extreme drought periods, there is very little difference in Hartwell and JST Reservoir elevations between A3 and A4 and NAA/A1. The minor differences in reservoir elevations are not expected to result in additional adverse effects to the biological communities in the USACE Reservoirs or result in substantial changes to social or socioeconomic resources in the Savannah River Basin.

Analysis of JST Project flow releases for the April through December when the system was in drought (i.e., those years where the USACE's DP was triggered) reveal there would be little difference in downstream flow releases between alternatives. Differences between A3/A4 and NAA/A1 are less than +/-5 percent on an annual basis. The larger negative differences (i.e., A3/A4 average flows are less than NAA/A1 flows) tend to occur during less severe drought years when average flows are well above 4,200 cfs. The larger positive differences tend to occur during recovery from extreme drought periods. JST flow releases under A3 and A4 are more similar to NAA/A1 than are the releases in A2.

As discussed in Section 3.3.3, state and/or federal regulatory agencies in Georgia and/or South Carolina may request implementation of adaptive management flow releases at the JST Project when JST flow releases fall below 3,800 cfs (i.e., during DP Levels 2, 3, and 4) to support downstream water quality. As a result, the small differences in April through December average

JST flow releases between A3/A4 and NAA/A1 (i.e., +/-5 percent) would be even smaller under adaptive management flow releases. As described in Section 3.4, Duke Energy can support adaptive management JST flow releases the majority of the time by scheduled weekly flow releases from Keowee Hydroelectric Station. During extreme drought periods when Duke Energy's remaining usable storage drops below 12 percent, a minimum of 650 ac-ft of water per week would continue to flow into Hartwell Lake via leakage and seepage from the Keowee Development. This water volume release to Hartwell Lake each week would help keep Duke Energy's system storage in balance with the USACE's system storage (within approximately 1 percent) during extreme drought periods. Therefore, in the event higher JST flow releases are needed for water quality purposes during extreme droughts, the remaining usable storage in the Duke Energy system under A3 and A4 could be used to support higher JST flow releases.

Under A3 and A4, adaptive management flow releases to address downstream water quality concerns during extreme drought conditions may result in slightly lower Hartwell and JST Lake elevations (by less than 0.4 feet in each reservoir). For A3, these slightly lower lake elevations are offset by Duke Energy's funding support for Phase 3 of the USACE's Comprehensive Study and public boating access improvements at Hartwell and JST Lakes. These funding measures are directly related to enhancing drought tolerance in the Upper Savannah River Basin and improving recreation opportunities on the USACE Reservoirs that would be affected by Keowee-Toxaway Project operations during drought periods. Similar funding measures are not included in A4.

For the Duke Energy system, A3 and A4 generally result in higher reservoir elevations throughout the 73-year POR for Lakes Jocassee and Keowee compared to the other alternatives. A3 and A4 provide additional usable storage in Lakes Jocassee and Keowee compared to A2. This is a result of deeper allowable maximum drawdowns (compared to A2) in Lakes Jocassee and Keowee and additional usable storage from the Bad Creek Project. This additional usable storage reduces the risk of forced outages at ONS during extreme drought periods (thus preventing expensive energy replacement costs and transmission system upgrade costs); provides additional storage that can be used to support other water users in the Upper Savannah River

Basin; and provides additional downstream flow releases to the USACE system (compared to current operating conditions) during the deepest parts of extreme drought periods.

In summary, A3 and A4 are better from a Duke Energy system operations perspective than NAA, A1 or A2. Adverse impacts to the USACE reservoir system during drought events are offset by the funding measures described above. A4 does not include the Keowee-Toxaway Project LIP (drought tolerance measure). For these reasons, Duke Energy believes A3 should be the Selected Alternative.

Recreation Impacts

The alternatives would affect the pool elevation in both the Duke Energy system and the USACE reservoir system. Those differences in pool levels would affect the usability of the boat ramps during droughts and, thus, the availability of the reservoirs to recreational users. In general, A2, A3, and A4 maintain higher pool levels in the Duke reservoirs when compared to NAA and A1. With A3 and A4, boat ramps in the Duke reservoirs would be available nearly every day over the period of analysis.

Pools in the USACE system would generally be higher during droughts with A2, but lower with A3, and A4, when compared to NAA and A1. Without mitigation, access to the USACE reservoirs would decline by 6.4 percent for A3 and 7.0 percent for A4. Mitigation is included in the alternatives to provide boating access and this mitigation would fully compensate for the expected impacts.

Releases Downstream of Thurmond Dam

Since USACE would continue to operate by its 2012 Drought Plan, all alternatives would produce similar discharge volumes from the JST Project to the lower Savannah River. The duration at which the reduced flows specified in the Drought Plan would occur would vary between alternatives. To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor from A2 and A3, USACE and Duke Energy would discharge 200 cubic feet per second of water above that specified in the 2012 Drought Plan from their dams for 11 days each year when the USACE reservoirs are in drought status during the summer months.

Recommended Alternative

Alternative 3 is recommended because it best balances the competing interests of reservoir levels, downstream flow releases, hydroelectric generation, risks to ONS operations, social and biological communities, recreation, and economic costs. Tables ES-2 and ES-3 provide a summary of HEC-ResSim, economic, environmental and socioeconomic results.

USACE would continue to operate by its 2012 Drought Plan, resulting in similar discharge volumes from the JST Project to the lower Savannah River. The USACE system would be in a drought status for slightly longer periods than in the NAA.

Table ES-2 HEC-ResSim and Economic Results Summary (Future Water Withdrawals with Historic Hydrology)

Resource		Alternatives				
		NAA	A1	A2	A3	A4
Duke Energy Avg Reservoir Elevation (ft AMSL)	Lake Jocassee	1104.6	1104.6	1105.0	1106.4	1106.3
	Lake Keowee	797.7	797.7	797.9	798.4	798.4
USACE Avg Reservoir Elevation (ft AMSL)	Hartwell Lake	656.9	656.9	657.0	656.8	656.7
	RBR Lake	475.5	475.5	475.5	475.2	475.2
	JST Lake	327.1	327.1	327.1	327.1	327.0
Minimum Remaining Usable Storage (%)	Duke Energy	17	17	42	11	10
	USACE	16	16	20	13	13
Socioeconomic Loss ($ / Jobs)	Lake Keowee	12,000 / 12	12,000 / 12	4,000 / 4	6,000 / 6	6,000 / 6
	Hartwell Lake	30,000 / 25	30,000 / 25	28,000 / 24	30,000 / 26	31,000 / 27
	JST Lake	500,000 / 650	500,000 / 650	510,000 / 660	510,000 / 660	510,000 / 660
Average Annual Net Hydroelectric Generation ($ Million)	Duke Energy	92.1	92.1	91.1	91.9	92.2
	USACE	120.4	120.4	120.4	120.4	120.4
ONS Economic Impacts ($ Million)	Replacement Energy	913	n/a	n/a	n/a	n/a
	Transmission System Upgrades	232	n/a	n/a	n/a	n/a
	Station Modifications	n/a	>800	n/a	2	2
JST Project Avg Flow Releases (cfs)		6,074	6,074	6,076	6,082	6,078
Days in USACE Drought Status	Level 1	2,033	2,033	2,037	2,198	2,189
	Level 2	3,858	3,858	3,866	4,106	4,158
	Level 3	598	598	574	742	770
	Total	6,489	6,489	6,477	7,046	7,117

Table ES-3 Environmental and Socioeconomic Results Summary (Future Water Withdrawals with Historic Hydrology)

Resource		Modeling Parameter	Alternative Comparison with NAA / A1		
			A2	A3	A4
Water Supply	Water Intake Operation	Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); smaller drawdowns for the Duke Energy System; alternative includes measures to reduce consumptive water uses at Keowee during droughts	Little to no difference (<1 ft); smaller drawdowns for the Duke Energy System
		Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
Water Quality	Reservoir Temperature and DO Stratification	Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); smaller drawdowns for the Duke Energy System	Little to no difference (<1 ft); smaller drawdowns for the Duke Energy System
	Lower Savannah River DO and Salinity	Average JST Flow Release	Little to no difference	Little to no difference	Little to no difference
Recreation	Public Boat-Launching Ramps	Daily Average Drawdown Elevation	Slight increase in annual usability	Small decrease (<2% of days) in annual usability; alternative includes measures to enhance boating facilities at Hartwell and JST	Small decrease (<2% of days) in annual usability; alternative includes measures to enhance boating facilities at Hartwell and JST
	Swimming		Small increase (<0.5 ft) in annual usability of swimming areas in USACE System during droughts	Small decrease (<1 ft) in annual usability of swimming areas in USACE System during droughts	Small decrease (<1 ft) in annual usability of swimming areas in USACE System during droughts
Biotic Communities - Reservoirs	Littoral Zone Fish and Mussel Habitat	Daily Average Reservoir Fluctuations	Little to no difference (< 0.01 ft)	Little to no difference (<0.01 ft)	Little to no difference (<0.01 ft)

Resource		Modeling Parameter	Alternative Comparison with NAA / A1		
			A2	A3	A4
	Pelagic Zone Fish Habitat	Mean September Drawdown Elevation	Little to no difference (infrequent larger drawdowns (<2 ft) at Lake Jocassee; studies find lake elevation alone is not a limiting factor to pelagic fisheries	Smaller drawdowns at Duke Energy System; Little to no difference at USACE System	Smaller drawdowns at Duke Energy System; Little to no difference at USACE System
	Aquatic Plants, Wetlands and Wildlife	Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); smaller drawdowns at Lake Jocassee	Little to no difference (<1 ft); smaller drawdowns at Lake Jocassee
Biotic Communities-Lower Savannah River	Fish and Mussel Habitat	Average JST Flow Release	Higher mean monthly flows for late winter and critical summer species; lower mean monthly flows for spring spawning and fall juvenile fish outmigration	Higher mean monthly flows for late winter and critical summer species; lower mean monthly flows for spring spawning and fall juvenile fish outmigration	Higher mean monthly flows late winter and critical summer species; lower mean monthly flows for spring spawning and fall juvenile fish outmigration
	Aquatic Plants, Wetlands and Wildlife	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
	Savannah National Wildlife Refuge	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
	Protected Species	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
Environmental Justice and Protection of Children, Cultural Resources, Coastal Zone Consistency, Solid and Hazardous Waste Facilities, and Navigation	Human Health, Environmental Effects, and Economic Hardship, Historic Properties	Reservoirs - Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); smaller drawdown for the Duke Energy System	Little to no difference (<1 ft); smaller drawdowns for the Duke Energy System
		Lower Savannah River - Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)

1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Introduction

1.1.1 *History*

On October 1, 1968, the U.S. Army Corps of Engineers – Savannah District (USACE) and the Southeastern Power Administration (SEPA) entered into an Operating Agreement (1968 Agreement) with Duke Energy Carolinas, LLC's (Duke Energy) predecessor company, Duke Power Company regarding water releases from Duke Energy's Keowee-Toxaway Hydroelectric Project No. 2503 (Keowee-Toxaway Project). The 1968 Agreement was intended to describe how Duke Energy would operate its Keowee-Toxaway Project in a manner that did not impair the ability of USACE and SEPA to meet their hydropower generating requirements. The 1968 Agreement recognizes a requirement for minimum flow releases from the USACE's most downstream project (J. Strom Thurmond [JST Project]) and other responsibilities, including flood control, in connection with the USACE's Hartwell and J. Strom Thurmond Projects. The 1968 Agreement is based on equalizing the percentage of remaining usable storage in the USACE's Hartwell and JST Reservoirs with the percentage of remaining usable storage in Duke Energy's Jocassee and Keowee Lakes on a weekly basis.

The 1968 Agreement includes a minimum reservoir elevation at Lake Keowee of 778 feet above mean sea level (ft AMSL) (Full Pool Elevation is 800 ft AMSL) with an allowance for a pumping volume down to elevation 775 ft AMSL. This minimum elevation was stipulated by the Federal Power Commission (FPC) (present-day Federal Energy Regulatory Commission [FERC]) when Lake Keowee was originally constructed during the late 1960s.

During the 1970s, Duke Energy constructed the 2,538-megawatt (MW) Oconee Nuclear Station (ONS) on the shores of Lake Keowee. The ONS uses a once-through condenser circulating water (CCW) system to operate its three reactor units. This system relies on water stored in Lake Keowee to support normal station operations and emergency operating situations. As a result of Nuclear Regulatory Commission (NRC) regulations, the ONS plant safety margin is decreased if Lake Keowee's surface elevation drops below 793.7 ft AMSL. The plant is required to manage this increase in risk by minimizing the amount of time below this reservoir elevation and restricting certain maintenance activities. To allow for a small operating margin above 793.7 ft AMSL, Duke added an additional 0.9 ft in the minimum pool elevation, resulting in a minimum target reservoir elevation of 794.6 ft AMSL. Duke's commitments in the licensing of the ONS require it to temporarily cease operation of ONS if the reservoir elevation declines below 793 ft AMSL if certain plant system conditions exist. These additional operating limitations related to ONS effectively reduced the usable storage volume in Lake Keowee significantly.

Operation of the Keowee-Toxaway, Hartwell, and JST Projects has also been affected by the construction of additional hydroelectric facilities by both USACE and Duke. In 1985, USACE began operating the Richard B. Russell Project, a pumped storage station located between the Hartwell and JST Projects. In 1991, Duke Energy's Bad Creek Pumped Storage Station (Bad Creek Project) began operations on a tributary to Lake Jocassee. Construction of these hydroelectric developments changed the usable storage volume of the system, but this volume of water has not been incorporated into the remaining usable storage calculations. Operations have been further modified by the USACE implementation of its Drought Plan (DP) in 1989, an action it implemented after the 1986-1989 drought and further revised after subsequent droughts (1998-2002, 2007-2009, and 2011-2012).

Duke Energy's FERC license for the Keowee-Toxaway Project expires in 2016. Duke Energy has been coordinating a diverse group of stakeholders, including Federal, state and local government agencies, water suppliers, and non-governmental organizations interested in the Keowee-Toxaway Project's concerning relicensing of that facility. Duke and those stakeholders are attempting to identify how the Keowee-Toxaway Project can be operated for hydropower in the future while better supporting future water supply needs in the region. As a result of those discussions and the expected relicensing, it is likely that the Keowee-Toxaway Project will be operated differently in the future compared to when the 1968 Agreement was developed.

As a result, USACE, SEPA and Duke Energy have worked together to develop a New Operating Agreement (NOA) to reflect these changed conditions. This Environmental Assessment (EA) is part of USACE and SEPA's evaluation of such an agreement under the National Environmental Policy Act (NEPA).

1.1.2 *Objective*

The general objective of the proposed action is to update the 1968 Agreement to reflect current Duke Energy and USACE hydroelectric project operations, and current conditions in the basin.

1.2 Purpose and Need

The purpose and need for this proposed action is to update and revise the 1968 Operating Agreement to reflect conditions that have changed since the 1968 Agreement, including the addition of the USACE's Richard B. Russell Project, the Duke Energy's Bad Creek Pumped Storage Project, the Duke Energy's ONS, and the USACE Drought Plan.

1.2.1 *ONS Operational Constraint*

Currently, Duke Energy must maintain Lake Keowee at a reservoir elevation of 794.6 ft AMSL or higher (Full Pool Elevation is 800 ft AMSL) for it to continue to operate the ONS with no special limitations. That elevation allows a small amount of operating margin above the 793.7 ft AMSL elevation where the plant safety margin is decreased under certain conditions. To comply with the license for the ONS from the Nuclear Regulatory Commission (NRC), Duke would need to shut down the ONS when Lake Keowee is below an elevation of 793 ft AMSL if certain plant system conditions exist. A summary of reservoir elevation restrictions is as follows:

- Below 793.7 ft AMSL, plant safety risks relative to water availability are increased, but shutdown is not required. ONS is required to minimize risk by limiting the amount of time below this level and by restricting maintenance activities on certain systems.
- Below 793 ft AMSL, shutdown may be required, depending on the configuration of certain pumps and controls.
- Below 791 ft AMSL, shutdown is required within a short amount of time. In addition, fire protection water supply loses redundancy (i.e., only one pump available).

- Below 787 ft AMSL, Keowee Hydroelectric Station generators will have less than seven days of water supply for generation as the emergency power source for ONS.
- All levels mentioned above do not include measurement error. ONS is required to assume measurement error based in the worst-case direction (i.e., higher) for all reservoir elevation measurements. This requires adding 0.5 foot (ft) (e.g., 793.7 + 0.5 = 794.2 ft AMSL) when using control room computer indications. Adding 0.4 ft above 794.2 ft AMSL, Duke Energy's Hydro Operations uses 794.6 ft AMSL as its operating threshold to make sure Lake Keowee remains above 794.2 ft AMSL at all times, taking into account possible operator error, wind and wave conditions, etc. Consequently, Duke Energy maintains Lake Keowee above a reservoir elevation of 794.6 ft AMSL for ONS to continue operating with no special limitations.

Additional information related to reservoir elevation restrictions can be found on the following page in Table 1.2-1.

There are three important technical issues concerning Lake Keowee pool elevations and the ONS, as follows:

- Several pumps important to ONS safety have inadequate suction pressure below certain reservoir elevations (793 or 791 ft AMSL, depending on configuration). Most of the suction piping is underground or buried in the concrete floor of the Turbine Building basement.
- Water inventory in Lake Keowee must allow for at least seven days of Keowee Hydroelectric Station generation during certain emergency situations involving loss of normal alternating current (AC) power to ONS. This requires Lake Keowee to be at or above 787 ft AMSL.

Table 1.2-1 Lake Keowee Level Restrictions and Required Actions

Reservoir Elevation (ft AMSL)	Condition	Required Action
<793.7	Inadequate reservoir elevation to support CCW System gravity-induced reverse flow.	Shutdown not required. Track unavailability for Maintenance Rule performance monitoring and manage increase in plant risk (e.g., avoid planned maintenance on some systems/equipment).
<793	Inadequate suction head for Low Pressure Service Water (LPSW) pumps under some conditions (i.e., High Pressure Service Water [HPSW] pump B out of service or HPSW pump A set to automatically start before HPSW pump B).	Shutdown required within 12 hours if any LPSW pump is inoperable. Otherwise, shutdown may be required within 84 hours depending on HPSW pump alignment.
<791	Inadequate suction head for LPSW pumps and HPSW pump A under design basis accident conditions.	Shutdown required within 12 hours if any LPSW pump is inoperable. Otherwise, shutdown is required within 84 hours. Within 7 days, develop guidance for loss of redundancy in Fire Protection Water Supply System.
<790	Both control room ventilation system chillers are inoperable due to potential air de-entrainment in suction piping to Chiller Condenser Service Water pumps.	Shutdown required within 12 hours.
<789	Inadequate suction head for HPSW pump B.	Establish backup Fire Suppression Water Supply System within 24 hours or shut down within 36 hours.
<787	Inadequate water supply for Keowee Hydroelectric Station to operate for 7 days in an emergency.	Cease commercial power generation of Keowee Hydroelectric Station.
<787	Potential failure of CCW piping to Radwaste Equipment Cooling System could adversely affect Emergency CCW siphon headers.	Isolate supply to Radwaste Equipment Cooling System or declare Emergency CCW siphon headers to be inoperable. May require shutdown depending on number of operable siphon headers.
<786	Emergency CCW siphon headers are designed for reservoir elevation ≥786 ft AMSL. Therefore, all siphon headers are inoperable.	Shutdown within 12 hours.
<783	Keowee Oil Storage Room Water Spray System is inoperable.	Shutdown not required. Compensatory measures required by Fire Protection Program.
<780	Keowee Step-Up Transformer Fire Protection Water Supply System is inoperable.	Shutdown not required. Compensatory measures required by Fire Protection Program.

Source: Harris 2009

Note: To illustrate the effects of decreasing reservoir elevation, the required actions for each reservoir elevation in the table are intended to stand alone, without regard to the required actions at other reservoir elevations.

- The 793.7 ft AMSL restriction involves flow by gravity through underground piping (six 11-ft diameter pipes about 1,000 feet long and several feet underground) during certain ONS conditions. The limit is a function of the pipe elevation. Plant modifications are planned that will reduce the safety importance of this issue and provide more flexibility. These planned modifications are incorporated into Alternatives 3 and 4 (A3 and A4) analyzed in this report.

1.2.2 *Additional Hydroelectric Project Usable Storage*

Both Duke Energy and the USACE have constructed pumped storage facilities in the Upper Savannah River Basin since the 1968 Agreement. Duke Energy's Bad Creek Project is located on a tributary to Lake Jocassee and uses Lake Jocassee as its lower reservoir. The Bad Creek Project has affected Duke Energy's operation of the Jocassee Pumped Storage Station. The USACE's RBR Project is located immediately downstream of the Hartwell Project and uses JST Lake as its lower reservoir.

1.2.3 *USACE Drought Plan*

USACE implemented its Drought Plan in 1989 to address water management during periods of drought. The DP includes four stages, each of which results in successively reduced discharges from JST Dam when certain reservoir elevation trigger levels are reached at Hartwell Lake and JST Lake. The DP has been modified several times since it was implemented, with the most recent revision effective as of July 2012. The 1968 Agreement does not address the DP. All modeling described in this Comprehensive Report incorporates the July 2012 revision of the USACE's DP.

1.2.4 *Keowee-Toxaway FERC Relicensing*

The Keowee-Toxaway Project was licensed by the Federal Power Commission, the FERC's predecessor agency, in 1966 for 50 years. The Keowee-Toxaway Project consists of the Jocassee Pumped Storage Development and Keowee Hydroelectric Development, which are both located on the Keowee River tributary near the headwaters of the eastern arm of the Savannah River

Basin. Duke Energy is using the FERC's default relicensing process, known as the Integrated Licensing Process (ILP), to develop its application for new license. The current FERC license (Existing License) expires in 2016. In accordance with the FERC's relicensing requirements, Duke Energy must submit its license application no later than August 31, 2014.

In developing its license application, Duke Energy has consulted extensively with a Stakeholder Team comprised of state and Federal agencies (including USACE and SEPA), local governments, Native American tribes, non-governmental organizations, and citizen groups. As part of that consultation, Duke Energy shared with its stakeholders the analyses it had performed for the development of a NOA with USACE and SEPA. Those stakeholders identified additional reservoir operating scenarios that Duke had not considered. The feedback from those stakeholders has been incorporated into the alternatives evaluated in this EA.

In November 2013, Duke Energy and sixteen other organizations signed a Relicensing Agreement (RA), a legally binding contract, recommending how the Keowee-Toxaway Project reservoirs (Lakes Jocassee and Keowee) should be operated under a new license.

The operations protocols in the RA include a Low Inflow Protocol (LIP) specifying how Duke Energy will operate the Keowee-Toxaway Project during droughts. The LIP includes five stages based on specific triggers (i.e., remaining usable storage and DP levels, streamflows, and the U.S. Drought Monitor). The LIP also limits reservoir drawdowns and downstream flow releases from the Keowee Development based upon the specific LIP stage. Since those protocols were developed in 2013, they are not included in the 1968 Agreement.

1.3 Scope

This EA assesses the potential environmental, engineering, and economic impacts that would result from implementing five different alternatives. The analyses estimate outcomes resulting from various operating scenarios and use records of historical rainfall in the basin. Many uncertainties exist when one applies the operating scenario modeling inputs and historical records to the future. The analyses presented in this report are highly dependent on the assumptions made, but they comprise the best analysis that USACE, SEPA, and Duke could perform of future water management-related activities. The analyses do not address potential future changes in regulatory requirements, resource agency policies, environmental conditions (other than the specific climate change sensitivities modeled), or other changes that may occur during the 50-year period of evaluation. The timing and magnitude of the growth of consumptive water use may differ from the model inputs. Further, the computer modeling used to evaluate the effects of the operational scenarios is neither intended nor capable of predicting the timing of specific events. However, the analyses are well suited for comparing the likely effects of various alternate operational scenarios with each other and with those expected to result from application of the existing 1968 Operating Agreement in the future.

A brief summary of the five alternatives evaluated in this Environmental Assessment is provided below (a more detailed summary of each alternative is provided in Section 3.1):

No Action Alternative (NAA)

The NAA represents operating the USACE and Duke Energy systems in accordance with the 1968 Agreement with no changes. The 1968 Agreement is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell and JST Reservoirs with the percentage of combined remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee. On a weekly basis, USACE determines the required water releases (or non-release) from Hartwell, RBR, JST, and Keowee for the upcoming week. The NAA assumes ONS regulatory commitments would require the ONS to be shut down if the Lake Keowee reservoir elevation is below 793 ft AMSL. The NAA incorporates the most recent version (July 2012) of the USACE's DP operating protocols.

Alternative 1 (A1)

In Alternative 1, Duke Energy would modify the ONS to allow it to meet the flow requirements of the 1968 Agreement so that the ONS could continue to operate down to a Lake Keowee pool elevation of 778 ft AMSL. As with the NAA, A1 incorporates the USACE's July 2012 DP operating protocols. A1 is based on the concept of equalizing the percentage of remaining usable storage capacity at the USACE's Hartwell and JST Reservoirs with the percentage of remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee. From a modeling perspective, A1 is identical to the NAA, and therefore, model results are referred to as NAA/A1. A1 also includes provisions to enhance drought tolerance in the Upper Savannah River Basin.

Alternative 2 (A2)

Alternative 2 represents how Duke has operated the Keowee-Toxaway Project since the mid- to late-1990s, particularly during extreme drought conditions. For A2, the overall methodology used to determine required weekly water releases from Lake Keowee would be the same as the NAA. However, no water would be released from Lake Keowee if that release would result in a Lake Keowee elevation below 794.6 ft AMSL. As with the NAA, A2 incorporates the USACE's July 2012 DP operating protocols. A2 is also based on the concept of equalizing the percentage of remaining usable storage capacity at the USACE's Hartwell and JST Reservoirs with the percentage of remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee. A2 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

Alternative 3 (A3)

While the NAA's overall concept of balancing the percentage of combined remaining usable storage between the Duke Energy and USACE Reservoirs is unchanged in A3, A3 incorporates updated storage volumes, coordinated drought response, measures to protect Upper Savannah River Basin water supply, and provisions of the Keowee-Toxaway RA. As with the NAA, A3 incorporates the USACE's July 2012 DP operating protocols.

In A3, Duke Energy would modify the ONS to allow normal operations to continue at Lake Keowee elevations below the current 794.6 ft AMSL limitation, with the minimum elevation for Lake Keowee for calculating usable storage being revised to elevation 790 ft AMSL (allowing a 10-ft drawdown of Lake Keowee). The Lake Jocassee minimum reservoir elevation would be lowered six feet (from 1086 ft AMSL to 1080 ft AMSL) and the allowance for pumping volume would be eliminated in the weekly water release calculation. A3 incorporates the additional storage capacity created by USACE and Duke Energy since the 1968 Agreement was executed, (the Bad Creek and RBR Reservoirs) for determining the remaining usable storage and weekly water release from Lake Keowee. A3 is based on the concept of equalizing the percent of combined remaining usable storage capacity at the USACE Reservoirs (Hartwell, RBR, and JST) with the percent of combined remaining usable storage capacity at the Duke Energy Reservoirs[1] (Bad Creek Reservoir and Lakes Jocassee and Keowee). A3 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

<u>Alternative 4 (A4)</u>

A4 was included to evaluate how Duke's LIP operations under A3 affect reservoir levels and flow releases from the USACE JST Project. Accordingly, A4 includes the same reservoir usable storage updates as A3, but does not include the Keowee-Toxaway Project LIP provisions found in A3. As with the NAA, A4 incorporates the USACE's July 2012 DP operating protocols. A4 is also based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell, RBR, and JST Reservoirs with the percentage of combined remaining usable storage capacity at Duke Energy's Bad Creek Reservoir and Lakes Jocassee and Keowee. A4 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

[1] Duke Energy Reservoirs is defined as Bad Creek Reservoir, Lake Jocassee, and Lake Keowee and is used only when referring to A3 and/or A4 results and/or discussion.

1.4 Study Methodology

To evaluate the differences between the five alternatives from a water management perspective, the USACE's Hydrologic Engineering Center's Reservoir System Simulation (HEC-ResSim) model was used to develop four modeling scenarios. From a reservoir operations perspective, the NAA and A1 are identical, so one modeling scenario represents both of those alternatives. USACE developed a HEC-ResSim model for its three reservoir projects on the Savannah River (i.e., Hartwell, RBR, and JST). The USACE model setup originally included general features associated with Lakes Jocassee and Keowee such as drainage areas, reservoir volumes, general operating rules, and flow releases from each development. In order to model the four scenarios more accurately, Duke Energy refined the model for Lake Jocassee, Lake Keowee, and the Bad Creek Project. These refinements include updated water volumes calculated from updated bathymetry for Lakes Jocassee and Keowee, more detail on reservoir operating rules for high water management and water conservation modes of operation, additional logic on pumped storage operations at the Jocassee Pumped Storage Station and the Bad Creek Project, and derived unimpaired inflows to each reservoir. These refinements also include water withdrawals from each development, including existing (Year 2010) and projected future (2016-2066) water withdrawals from (and returns to) each development for all registered water use entities, including the cities of Greenville and Seneca, South Carolina. Appendix A summarizes the present and future water use projections that were used in this analysis.

USACE, SEPA, and Duke agreed to adopt and expand the unimpaired hydrologic dataset (UIF) being developed by ARCADIS for the Georgia Department of Natural Resources Environmental Protection Division (GA DNR-EPD). Duke first expanded the UIF to include the historic operations of its facilities from 1939-2008. The UIF for the entire Savannah River Basin was then expanded through 2011. Once the operations model was updated with the enhanced project information and outflows from the new UIF, the model was verified against available historic flow and generation records. The verification process ensured the model was an adequate representation of the Savannah River Basin from the Bad Creek Reservoir downstream to the outlet of the Thurmond Reservoir.

Results from the revised Savannah River HEC-ResSim model and inflow hydrology were then used to compare reservoir elevations, generation, and flow releases at the Duke Energy and USACE projects resulting from the four operating scenarios. Reservoir elevation results and simulated flow releases from the JST Project to the lower Savannah River from the HEC-ResSim model were also used to evaluate potential impacts to downstream environmental and economic issues.

When the Draft EA was released, the modeling analysis and results had not yet been thoroughly reviewed by all stakeholders. That review occurred through coordination of the Draft EA. During the Draft EA review period, USACE performed additional hydrologic modeling with an upgraded version of the Savannah River HEC-ResSim model. The results from using the updated model were shared with the hydraulic modelers in the natural resource agencies (regulating agencies). The results did not differ markedly from what was shown in the Draft EA, but the model performed more reliably and better reflected how the USACE water managers would operate their reservoirs. The differences between the model outputs did not warrant substitution of the updated model's performance numbers in this Final EA since the new numbers did not substantially alter the impacts identified or the plan selection. As a result of this additional modeling work and coordination, the natural resource agencies are comfortable with the reliability of the ResSim hydrologic model and the evaluations of potential environmental impacts of the alternatives in this EA.

2.0 AFFECTED ENVIRONMENT

2.1 Description of the Savannah River Basin

2.1.1 *Land Use Characteristics*

The Savannah River Basin has a total surface area of approximately 10,577 square miles. The total surface area is comprised of approximately 5,821 square miles in Georgia, 4,581 square miles in South Carolina, and 175 square miles in North Carolina. The study area, which extends from the headwaters of the Keowee-Toxaway Project downstream to Savannah Harbor and the Atlantic Ocean, drains portions of three physiographic provinces: the Blue Ridge, the Piedmont, and the Coastal Plain. Land use and land cover types vary, with evergreen forest, deciduous forest, and agriculture being the dominant land covers in the basin (Table 2.1-1).

Table 2.1-1 Savannah River Basin Land Cover and Use Statistics (1998 Data)

Land Cover Type	Percentage (%)
Beach	0.02
Water	3.88
Suburban	2.34
Commercial	1.81
Clearcut	7.66
Mines, rock outcrops	0.15
Deciduous forest	19.43
Evergreen forest	27.84
Mixed forest	8.70
Agriculture	19.46
Wetlands	8.71
Total	100.0

Source: Loeffler and Meyer 2010

2.1.2 *Drainage Basin Characteristics*

In the upper reaches of the Savannah River Basin, part of the flow is regulated by three reservoirs owned and operated by Duke Energy: Bad Creek Reservoir, Lake Jocassee, and Lake Keowee (Figure 2.1-1). These reservoirs drain approximately 435 square miles of the basin, approximately four percent of the overall Savannah River Basin drainage area.

The developments associated with Georgia Power Company's North Georgia Hydroelectric Project on the Tugaloo River drain about 473 square miles of the basin, approximately four percent of the overall Savannah River Basin drainage area. River flow is then regulated by three large, multipurpose USACE reservoirs (Hartwell, RBR, and JST) (Figure 2.1-1). These reservoirs are located along the border of Georgia and South Carolina and drain an incremental area of approximately 5,216 square miles of watershed, approximately 50 percent of the overall Savannah River Basin drainage area.

The lower Savannah River downstream of JST Dam drains the remaining 4,453 square miles, approximately 42 percent of the overall Savannah River Basin drainage area. Other impoundments/projects include the USACE's New Savannah Bluff Lock and Dam (NSBL&D), South Carolina Electric & Gas Company's (SCE&G) Stevens Creek Hydroelectric Project, and the reservoir created by the City of Augusta's Canal and Diversion Dam. Table 2.1-2 provides an overview of the hydroelectric projects in the Savannah River Basin.

Flow in the lower Savannah River (downstream of JST) varies considerably both seasonally and annually, even though it is largely controlled by flow releases from the Thurmond Dam, located approximately 20 miles northwest of Augusta, Georgia. Flows are typically high during the winter and early spring months, and lower during the summer and fall. Regulation by upstream reservoirs has reduced natural flow variations (USACE 2008a).

Figure 2.1-1 Savannah River Basin and Project Location

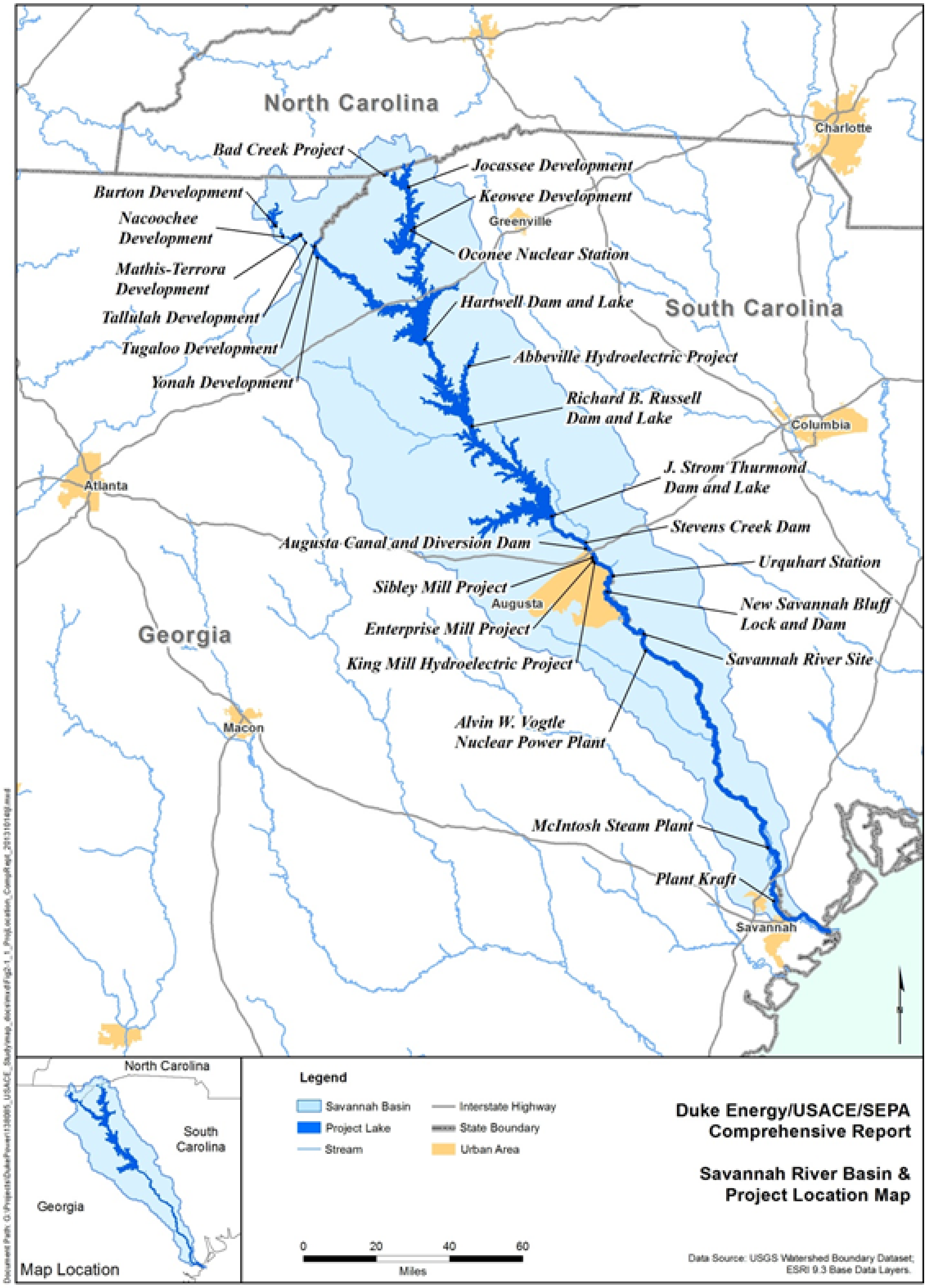


Table 2.1-2 Electrical Generating Facilities in the Savannah River Basin

Project Name	Owner / Operator	State	County	Waterbody	Usable Reservoir Storage Capacity (ac-ft)	Generating Capacity (MW)	Project Type[1]	License Expiration
Bad Creek	Duke Energy	SC	Oconee	Bad Creek	30,229	1,065	PS	2027
Jocassee	Duke Energy	NC, SC	Oconee, Pickens, Transylvania	Lake Jocassee	225,387	710.1	PS	2016
Oconee	Duke Energy	SC	Oconee	Lake Keowee	N/A	2,538	N	2033, 2034
Keowee	Duke Energy	SC	Pickens, Oconee	Lake Keowee	90,319[2]	157.5	H	2016
Hartwell	USACE	GA, SC	Hart, Franklin, Stephens Anderson, Oconee, Pickens	Hartwell Lake	1,415,500	422	H	N/A
Abbeville	City of Abbeville	SC	Abbeville, Anderson	Lake Secession	25,650	2.6	H	2037
John S. Rainey	Santee Cooper	SC	Anderson	Richard B. Russell	N/A	1100	O	N/A
Richard B. Russell	USACE	GA, SC	Elbert, Abbeville	Richard B. Russell Lake	126,864	660	PS	N/A
J. Strom Thurmond	USACE	GA, SC	Columbia, McCormick	J. Strom Thurmond Lake	1,044,908	380	H	N/A
New Savannah Bluff Lock and Dam[3]	USACE	GA, SC	Richmond, Aiken	Savannah River	N/A	N/A	O	N/A
Stevens Creek	South Carolina Electric & Gas Company	GA, SC	Columbia, McCormick, Edgefield	Stevens Creek, Savannah River	8,600	17.3	H	2025
Augusta Canal	City of Augusta	GA, SC	Richmond, Aiken	Augusta Canal	N/A	N/A	O	Pending
Sibley Mill	Avondale Mills Inc.	GA, SC	Richmond	Augusta Canal	N/A	2.46	H	2055
Enterprise Mill	Enterprise Mill Inc.	GA	Richmond	Augusta Canal	N/A	1.2	H	2055
King Mill	Augusta Canal Authority	GA	Richmond	Augusta Canal	N/A	2.25	H	2055
Urquhart	South Carolina Electric & Gas Company	SC	Aiken	Savannah River	N/A	650	O	N/A
Savannah River Site	DOE	SC	Aiken, Allendale, Barnwell	Savannah River	N/A	N/A	O	N/A
Vogtle	Southern Nuclear Operating Company	GA	Burke	Savannah River	N/A	2,400	N	2047, 2049
McIntosh	Southern Company	GA	Effingham	Savannah River	N/A	178	O	N/A
Kraft	Southern Company/Savannah Electric and Power Company	GA	Chatham	Savannah River	N/A	208	O	N/A
Burton	Georgia Power Company	GA	Rabun	Lake Burton	90,000	6.12	H	2036
Nacoochee	Georgia Power Company	GA	Rabun	Lake Seed	5,350	4.8	H	2036
Yonah	Georgia Power Company	GA/SC	Stephens, Oconee	Lake Yonah	6,000	22.5	H	2036
Mathis-Terrora	Georgia Power Company	GA	Rabun, Habersham	Lake Rabun	21,900	16	H	2036
Tallulah	Georgia Power Company	GA	Rabun	Tallulah Falls Lake	1,490	72	H	2036
Tugaloo	Georgia Power Company	GA, SC	Habersham, Oconee	Tugaloo Lake	14,000	45	H	2036
				Total	3,075,522	10,661		

[1] PS = Pumped Storage Hydroelectric, H = Conventional Hydroelectric, O = Other, N = Nuclear
[2]The usable capacity provided in this table is based on current 794.6 ft AMSL operating restriction at Lake Keowee. The storage capacity between full pond (800 ft AMSL) and the maximum drawdown listed in the 1968 Operating Agreement (778 ft AMSL) is 327,766 ac-ft. The storage capacity between full pond (800 ft AMSL) and the elevation Lake Keowee could operate down to with ONS modifications (790 ft AMSL) is 161,772 ac-ft.
[3]The NSBL&D does not include any hydropower generating facilities

2.1.3 ***Shoreline Management***

2.1.3.1 *Duke Energy Projects*

Duke Energy is responsible for managing activities within the reservoir boundaries of Lakes Jocassee and Keowee in a manner that promotes safe public use and maintains environmental safeguards. For safety reasons, Duke Energy does not allow any access to the Bad Creek Reservoir. Duke Energy maintains a Shoreline Management Plan (SMP) for Lakes Jocassee and Keowee that classifies the respective shorelines and denotes where environmentally important habitats exist, where existing facilities and uses occur, and where future construction activities may be considered (Duke Energy 2010).

As part of its SMP, Duke Energy maintains Shoreline Management Guidelines, which, when used in combination with the SMP shoreline classifications, guide responsible reservoir use activities (e.g., construction, stabilization, and excavation activities) within the reservoir boundaries. Typical activities include construction of private piers, multi-slip marinas, and conveyances; dredging efforts; and shoreline stabilization efforts.

2.1.3.2 *North Georgia Hydroelectric Project*

The Georgia Power Company (Georgia Power) is responsible for preserving the scenic, environmental, and recreational value of its reservoirs and it maintains Shoreline Management Guidelines regarding shoreline development that comply with Federal, state, and local laws and regulations. The guidelines include construction permit requirements for dwellings and additions, seawalls, docks, dredging, and residential shoreline use (Georgia Power 2008).

2.1.3.3 *USACE Projects*

USACE is responsible for managing development activities around the shoreline of Hartwell and JST Lakes in a manner that promotes safe public use and maintains environmental safeguards. USACE maintains SMPs for Hartwell and JST Lakes, which provide guidance and information to the public, specific to the effective management of the Hartwell and JST Project shorelines (USACE 2010a). The types of private uses and activities that are permitted on the shorelines are described within the SMPs. Additionally, the plans address shoreline allocations, rules, regulations, and other information relevant to the Hartwell and JST Projects.

The USACE manages and protects the shoreline of RBR Lake via its Shoreline Management Policy. This policy establishes and maintains acceptable fish and wildlife habitat, aesthetic quality and natural environmental conditions, and promotes the safe use of RBR Lake shorelines for recreational purposes by the public. Considerations are given to possible conflicts of use between the general public and the owners of private property adjacent to the project. The policy of the Chief of Engineers is that private exclusive use[2] is not permitted on reservoirs constructed after December 1974 (i.e., RBR Lake). Therefore, privately-owned boat docks, launching ramps, driveways, gardens, buildings, developed walkways, vista clearings, under-brushing, mowing, and other private lakeshore uses are not permitted.

2.1.3.4 *Lower Savannah River Basin*

2.1.3.4.1 South Carolina

The South Carolina Department of Health and Environmental Control (SC DHEC) administers the Water Quality Certification program pursuant to Section 401 of the Clean Water Act, 33 U.S.C. Section 1341. SC DHEC Regulation 61-101 establishes procedures and policies for implementing state water quality certification requirements and directs the SC DHEC in processing applications for certification. Section 401 requires the State to issue certification for any activity requiring a Federal permit which may result in a discharge to State waters. The certification must state that applicable effluent limits and water quality standards will not be violated (SC DHEC 1995). During its review of applications for Section 401 Water Quality Certification, SC DHEC considers:

- Whether the activity is water dependent;
- The intended purpose of the activity;
- Whether there are feasible alternatives to the activity; and
- All potential water quality impacts associated with the project, both direct and indirect, over the life of the project, including impacts on existing and classified uses; physical,

[2] Private exclusive use is defined as use of public land by adjacent private property owners that would lead the public to believe public land is privately owned (USACE 2011).

chemical, and biological impacts, including cumulative impacts; the effect on circulation patterns and water movement; and the cumulative impacts of the proposed activity and reasonably foreseen similar activities of the applicant and others (SC DHEC 2010).

SC DHEC may waive, issue with conditions, or deny a 401 Water Quality Certification. Certification is denied if the activity will have permanent adverse effects on existing or designated uses.

Activities that result in a discharge of dredged or fill material to waters or wetlands of the United States (U.S.) such as dam, levee, infrastructure, and mining projects, require a Federal Section 404 Clean Water Act permit. Because these activities result in discharge to waters, SC DHEC must also take certification action on all Section 404 permit applications affecting waters of the state. A Federal Section 404 permit cannot be issued without the associated state action of a Section 401 Water Quality Certification and/or a Coastal Zone Consistency determination. U.S. Coast Guard permits and FERC regulations also require states to take Water Quality Certification action.

2.1.3.4.2 Georgia

The GA DNR-EPD administers the Water Quality Certification program pursuant to Section 401 of the Clean Water Act in Georgia in a similar manner to SC DHEC in South Carolina. GA DNR regulations establish the procedures and policies that EPD follow in implementing the water quality certification program in Georgia. EPD considers similar factors and has similar rights and responsibilities as it administers the Section 401 program in Georgia.

2.1.4 *Population Characteristics*

The Savannah River Basin includes portions of 28 counties in Georgia, 13 counties in South Carolina and 4 counties in North Carolina. Although the basin is predominantly rural, metropolitan areas within the basin are experiencing approximately 25 to 35 percent more growth and development compared to national population growth rates. The growth is occurring primarily in areas of Anderson, South Carolina, and Augusta and Savannah, Georgia, as well as many smaller cities and towns.

According to historical data, the overall U.S. population grew at an average annual rate of 1.05 percent from 1970 through 2000 (HDR 2012). During this 30-year period, South Carolina and Georgia experienced statewide average annual growth rates of 1.46 percent and 1.89 percent, respectively. South Carolina and Georgia counties in the Savannah River Basin experienced average annual growth rates of 1.30 percent and 1.42 percent, respectively over the same period, as described in the Water Supply Study (HDR 2012) (Appendix A). Population growth for the counties in the Savannah River Basin from 1970 through 2000 is displayed in Table 2.1-3. That table also provides population density estimates. North Carolina population data was not included because there are only a few small tributaries located in the Savannah River Basin in North Carolina, and the only water withdrawals are small and for agricultural use.

Table 2.1-3 Savannah River Basin Population Estimates

State	No. of Counties in Basin	Drainage Basin Area (sq mi)	1970 Population Estimate (No. of People)	2010 Population Estimate (No. of People)	2010 Population Density (No. of People/sq mi)
South Carolina	13	4,558	459,785	771,800	169
Georgia	28	5,746	768,851	1,353,973	236
Total	41	10,304	1,228,636	2,125,773	206

Source: HDR 2012.

2.2 Duke Energy Projects

2.2.1 *Bad Creek Project*

The 1,065 Megawatt Bad Creek Project is located in Oconee County, approximately 8 miles northwest of Salem and 35 miles northwest of Greenville, South Carolina. Duke Energy was issued a license to construct the project (FERC No. 2740) by the FERC on August 1, 1977; the license will expire on July 31, 2027. The Bad Creek Project was constructed after the 1968 Agreement went into effect, therefore, its influence on water storage, timing of flow releases, and hydroelectric generation was not factored into the 1968 Agreement.

Lake Jocassee serves as the lower reservoir for the Bad Creek Project. The upper reservoir impounds the Bad Creek and West Bad Creek tributaries of Howard Creek, approximately one-mile west of the Whitewater River arm of Lake Jocassee and within several thousand feet of the North Carolina state line. The upper reservoir typically operates between the elevations of 2,310 and 2,250 ft AMSL and has a maximum drawdown elevation of 2,150 ft AMSL. The upper reservoir has a surface area of approximately 318 acres and a usable storage capacity of approximately 30,229 acre-feet (ac-ft) at full pool.

The Bad Creek Project is operated to generate power in a pumped storage mode. The plant typically generates power to meet peak demands a few hours per day. During off-peak hours, water is pumped from Lake Jocassee (lower reservoir) to Bad Creek (upper reservoir).

2.2.2 *Keowee-Toxaway Project*

The Keowee-Toxaway Project, situated on the southeastern slope of the Blue Ridge escarpment, consists of two developments (Jocassee Pumped Storage Development and Keowee Hydroelectric Development) located in the Upper Savannah River Basin in Pickens and Oconee counties, South Carolina, and Transylvania County, North Carolina. Lake Jocassee was flooded in 1973 and serves as the upper reservoir for the Jocassee Pumped Storage Development and the lower reservoir for the Bad Creek Project.[3] Lake Keowee was formed in 1971 by constructing a dam on the Keowee River and a dam on the Little River. The two basins are connected by an excavated canal. In addition to providing water for the production of hydroelectric power, Lake Keowee also serves as the lower reservoir for the Jocassee Pumped Storage Development and as a source for cooling water for ONS. Keowee Hydroelectric Station also serves as the back-up power supply for ONS in the case of a loss of off-site power. The FERC license for the Keowee-

[3] Although the Bad Creek Project and the Keowee-Toxaway Project operate in tandem by both using Lake Jocassee as either a lower or upper reservoir, the two projects have separate FERC Licenses.

Toxaway Project was issued on September 1, 1966 and expires on August 31, 2016. Duke Energy is currently in the relicensing process to obtain a new FERC license (New License) for the Keowee-Toxaway Project.

2.2.2.1 *Jocassee Pumped Storage Development*

The 710.1 MW Jocassee Pumped Storage Development is the upstream development of the Keowee-Toxaway Project and includes the Jocassee Pumped Storage Station, Lake Jocassee, Jocassee Dam, and two saddle dikes. The Jocassee Pumped Storage Development occupies lands in the Upstate area of South Carolina primarily in Oconee and Pickens counties with a small portion of Lake Jocassee extending into Transylvania County, North Carolina. The development is located on the Keowee River approximately 20 miles north of Seneca, South Carolina. The full pool elevation is 1,110 ft AMSL. At full pool, the reservoir has approximately 7,980 surface acres, 92.4 miles of shoreline and a gross storage volume of 1,206,798 ac-ft. The drainage area is 145 square miles. Commercial operation of Units 1 and 2 began in 1973, and operation of Units 3 and 4 began in 1975. The Jocassee Pumped Storage Development releases water directly into Lake Keowee.

Duke Energy has historically operated the Jocassee Pumped Storage Development to meet system electrical demand. Lake Jocassee operates within a range of a normal high of 1,110 ft to a low of 1,080 ft AMSL, but is typically operated within a range of approximately 1,096 ft AMSL and 1,110 ft AMSL when drought conditions do not exist. Because of the nature of pumped-storage operations, Lake Jocassee generally fluctuates approximately 0.8 ft or less with approximately 88 percent of the daily fluctuations less than 1.5 feet and virtually all daily fluctuations less than 2.9 feet during high electricity demand periods. The usable storage capacity based on the water storage volume between the Normal Full Pool Elevation and 1,080 ft AMSL is 225,387 ac-ft.

2.2.2.2 *Keowee Development*

The 157.5 MW Keowee Development is the downstream development of the Keowee-Toxaway Project and includes the Keowee Hydroelectric Station, Lake Keowee, Little River Dam, Keowee Dam, and four saddle dikes. The Keowee Development is located on the Keowee River approximately eight miles north of Seneca, South Carolina, in Pickens and Oconee counties. The full pool elevation is 800 ft AMSL. At full pool, the reservoir has approximately 17,660 surface acres, 388 miles of shoreline and a gross storage volume of 869,338 ac-ft. The drainage area is 435 square miles. Commercial operation of Units 1 and 2 began in 1971. Water released from the Keowee Hydroelectric Station flows directly into Hartwell Lake.

Duke Energy has historically operated the Keowee Development to meet standby emergency power needs for ONS and to meet system electrical demand. Under the Existing License, Lake Keowee is allowed to be operated within a range from a normal high of 800 ft to a low of 775 ft AMSL, with pumped storage operations. Based on NRC requirements for certain systems at ONS and other operating margin considerations, Lake Keowee is currently maintained at or above 794.6 ft AMSL. The Keowee Development is typically operated within a range of approximately 799.5 ft AMSL and 794.6 ft AMSL. Because of the nature of pumped-storage operations at the Jocassee Development, Lake Keowee generally fluctuates about 0.6 feet or less with approximately 86 percent of the daily fluctuations less than 1.0 foot and almost all daily fluctuations less than 1.8 feet during high electricity demand periods. The Lake Keowee calculation of usable storage at elevation 778 ft AMSL allowing for storage up to elevation 800 ft AMSL is 327,766 ac-ft.

2.2.3 *Oconee Nuclear Station*

ONS is located on Lake Keowee in Seneca, South Carolina, eight miles north of Clemson, South Carolina. The facility has three 846-MW pressurized light water reactors with a total generating capacity of 2,538 MW. Construction of the facility began in 1967. Unit 1 began commercial operation in 1973 followed by Units 2 and 3 in 1974. On May 23, 2000, the NRC renewed the licenses for all three reactors for an additional 20 years. The licenses for Units 1 and 2 expire on February 6, 2033, and the license for Unit 3 expires on July 19, 2034.

2.3 North Georgia Hydroelectric Project (Georgia Power Company)

Georgia Power owns the North Georgia Project (FERC No. 2354), consisting of six hydroelectric developments in the Savannah River Basin on the Tallulah and Tugaloo Rivers, as shown on

Figure 2.1-1. The North Georgia Project's FERC license is scheduled to expire on September 30, 2036. Based on the location of the North Georgia Project in relation to the Duke Energy and USACE projects, there are no anticipated impacts to the North Georgia Project of the alternatives evaluated in this EA. Additional information on the North Georgia developments is provided in Appendix B.

2.4 USACE Projects

For the purposes of marketing the power output of the USACE projects in the Savannah River Basin, SEPA combines the three Savannah District projects with seven Mobile District projects to form the Georgia-Alabama-South Carolina system. Generally, if one project is unable to provide the power production needed or expected, another project can be used to make up the shortage. Savannah District exercises water control management at the USACE projects within the Savannah River Basin. The water management decisions are made within the broader context of the larger power network for the Southeastern U.S.

2.4.1 *Hartwell Dam and Lake Project*

The 422 MW Hartwell Dam and Lake Project (Hartwell Project) is located on the Savannah River seven miles downstream from the confluence of the Tugaloo and Seneca Rivers forming the Savannah River. Hartwell Lake is located in Georgia (Hart, Franklin, and Stephens counties) and South Carolina (Anderson, Oconee, and Pickens counties). The Hartwell Project includes the Clemson Upper and Lower Diversion Dams, which were completed in 1967 to protect lowlands at Clemson University. The project has 1,416,000 ac-ft of usable storage capacity at a full pool elevation of 660 ft AMSL. The surface area at 660 ft AMSL is approximately 56,000 acres with a 962-mile shoreline. Project construction occurred from 1955 through 1963 and the first generator went on-line on April 27, 1962.

The authorized purposes of the Hartwell Project are to provide flood control, fish and wildlife habitat, water quality enhancement, water supply, recreation, and hydroelectric power. The Hartwell Project includes 35 feet of conservation storage from elevation 625 to 660 ft AMSL and 5 feet of flood control storage operation from an elevation of 660 to 665 ft AMSL. During the spring and early summer, the project has limited additional flood control storage. During normal conditions, all flow releases are made through the turbine units. The water control manager coordinates weekly (or more frequent, if necessary) water control actions with SEPA. Power produced from the Hartwell Project is sold through SEPA to public entities and cooperatives in the Southeastern U.S. From there, the power is provided to customers of those entities.

2.4.2 *Abbeville Hydroelectric Project (City of Abbeville, SC)*

The 2.6 MW Abbeville Hydroelectric Project (FERC No. 11286) is located on Rocky River, a tributary to the Savannah River, situated in Anderson and Abbeville counties. The Project was constructed in 1940 by the City of Abbeville and was issued a 30-year license by the FERC on December 24, 1997. The project functions as a peaking facility with electrical energy used by the City to offset power purchases from electrical wholesalers. The project reservoir (Lake Secession) has a surface area of approximately 1,362 acres with 25,650 ac-ft of usable water storage at full pond (548 ft AMSL). The project tailrace is affected by backwater from RBR Lake.

2.4.3 *RBR Dam and Lake Project*

The 660 MW Richard B. Russell Dam and Lake Project (RBR Project) is located in the Piedmont region of Georgia and South Carolina on the middle Savannah River. The project is located in Abbeville County, South Carolina and Elbert County, Georgia, 30 miles downstream from Hartwell Dam and 37 miles upstream from the JST Dam. Construction of the RBR Project began in 1974 and it began operating in 1985. The power plant originally consisted of four conventional generators. Four pump-back units were added in 1992 and commercial operation of the pump-back units began in July 2002. The authorized purposes of the RBR Project include hydroelectric generation, incidental flood control, water supply, water quality enhancement, recreation, and fish and wildlife habitat. The RBR Project was constructed after the 1968 Agreement went into effect, so its influence on water storage, timing of flow releases, and hydroelectric generation is not factored into that 1968 Agreement.

The reservoir has a flood pool elevation of 480 ft AMSL and 126,800 ac-ft of usable storage capacity. RBR Lake has a surface area of approximately 26,650 acres and 540 miles of shoreline at a Normal Pool Elevation of 475 ft AMSL. RBR includes 5 feet of conservation storage from elevation 470 to 475 ft AMSL and 5 feet of flood control storage operation from an elevation of 475 to 480 ft AMSL.

There are several operational restrictions in place at the RBR Project to minimize fish entrainment and impacts to fishery habitat. The operational restrictions include:

- Pumped storage operations are limited to the hours beginning one hour before official sunrise to one hour after official sunset.
- Between March 1 and March 31, the RBR Project is limited to one-unit operation and no pumped storage operations occur between April 1 and April 30 (not applicable to Level 2 drought conditions or greater).
- There are no seasonal pumped storage operational restrictions when a Level 2 drought is declared.
- Between May 1 and May 31, pumped storage operations include a maximum of one-unit operation. In the event that a Level 1 drought is declared, pumped storage operations are increased to a maximum of two units between May 16 and May 31.
- From May 16 through September 30, the USACE conducts a minimum of six unit-hours of generation, of not less than 60 MW, within the 12 hours preceding any pumped-storage operation.

USACE is still monitoring the effects of four unit pumpback operation on fishery resources.

2.4.4 *John S. Rainey Generating Station*

The 1,100 MW John S. Rainey Generating Station (Rainey Station) is located in Starr, South Carolina. The first phase of the Rainey Generating Station, a 500 MW combined cycle unit, began commercial operation in January 2002, and by May 2002, two 150 MW simple-cycle combustion turbines were also in service. The Rainey Station is Santee Cooper's first facility with gas as its primary fuel source and is planned for service through 2066.

2.4.5 ***JST Dam and Lake Project***

The 380 MW J. Strom Thurmond Dam and Lake Project (JST Project) is located on the Savannah River 22 miles upstream from Augusta, Georgia, and 239.5 miles upstream from the mouth of the Savannah River. JST Reservoir is located in Columbia, Lincoln and Elbert counties in Georgia; and McCormick and Abbeville counties in South Carolina. The reservoir extends 39.4 miles up the Savannah River, 29 miles up the Little River, 6.5 miles up the Broad River in Georgia, and 17 miles up the Little River in South Carolina. The project has 1,045,000 ac-ft of usable storage capacity, 1,200 miles of shoreline and approximately 71,000 surface acres of water at a normal pool elevation of 330 ft AMSL. The project was the first of the three USACE projects built in the Savannah River Basin and it was constructed from 1946 through 1954. Filling of JST began in July 1951 and was completed in October 1952. The power plant began commercial operation in November 1952.

The authorized purposes of the JST Project are to provide for flood control, fish and wildlife habitat, water quality enhancement, water supply, recreation, and hydroelectric power. The project has 18 feet of conservation storage from an elevation of 312 to 330 ft AMSL. The project has seasonal drawdowns of the conservation pool. Operations at the JST Project are similar to the operations at the Hartwell Project with the additional requirement of operating the gates at the NSBL&D. The power produced at the JST power plant is sold through SEPA. The JST power plant is operated primarily as a peaking plant to meet electric needs during peak demand hours.

The combined usable storage of Hartwell, RBR, and JST Lakes is 2,587,800 ac-ft.

2.5 Lower Savannah River Projects

The following projects are located on the Lower Savannah River in descending order between JST Dam and the Savannah Harbor as depicted in Figure 2.1-1 (with the exception of the NSBL&D Project, which is described in Section 2.57).

2.5.1 *Stevens Creek Project (South Carolina Electric & Gas Company)*

The 17.3 MW Stevens Creek Project (FERC No. 2535) is located at the confluence of Stevens Creek and the Savannah River in Edgefield and McCormick counties, South Carolina and Columbia County, Georgia. The project license was issued by the FERC on November 22, 1995 and expires on October 31, 2025. Stevens Creek is a run-of-river hydroelectric project, but it effectively functions as a re-regulating facility to smooth out the peaked flows discharged from the upstream JST Dam. The reservoir has a surface area of 2,400 acres and contains 23,700 ac-ft of water at full pool (187.5 ft AMSL) with 8,600 ac-ft of usable storage capacity. Construction of the project was completed in 1914.

SCE&G is required by Article 402 of the FERC license to operate the Stevens Creek Project to reach full pool in the Stevens Creek Reservoir by Friday evening and provide a continuous weekend discharge. Additional operational requirements include re-regulation of flow releases from the JST Dam (located upstream of the Stevens Creek Project) and releasing all JST Dam discharges on a weekly basis, and implementation of fish passage if/when they are effective at downstream dams. SCE&G is also required to obtain the predicted JST Dam discharge schedule from the USACE to limit reservoir fluctuations while maintaining the Stevens Creek Reservoir between elevations of 183 and 187 ft AMSL.

2.5.2 *Augusta Canal and Diversion Dam Project (City of Augusta, Georgia)*

The Augusta Canal Project (FERC No. 11810) has no hydroelectric generating facilities. On January 30, 2003, the City of Augusta, Georgia, filed an application with the FERC for a major license for the Augusta Canal Project. The License Application is still pending with the FERC. The South Carolina Department of Natural Resources (SC DNR) has requested the following seasonal aquatic-based flows (in cubic feet per second [cfs]) as part of the Water Quality Certification pursuant to § 401 of the Clean Water Act (Table 2.5-1).

Table 2.5-1 Seasonal Aquatic-Based Flows for Augusta Canal and Diversion Dam Project

Inflow (cfs)		Feb 1-Mar 31	Apr 1-30	May 1-15	May 16-31	Jun 1-Jan 31
Tier 1	≥5,400	3,300	3,300	2,500	1,900	1,900
Tier 2	4,500-5,399	2,300	2,200	1,800	1,800	1,500
Tier 3	3,600-4,499	2,000	2,000	1,500	1,500	1,500
Tier 4	<3,600	1,800	1,500	1,500	1,500	1,500

Source: SCDNR 2008.

The City of Augusta has indicated that it would comply with that request as best it could until a decision by FERC on the license. Natural resource agencies have also stated that the FERC license must include provision for fish passage if/when it is effective at the downstream dam.

The project currently provides hydro-mechanical power to pump raw drinking water to the City of Augusta's water treatment plant. The Augusta Canal also supplies water to the Sibley Mill, Enterprise Mill, and King Mill projects. Originally constructed in 1875, the project was modernized in 1979. The Augusta Diversion Dam is located at river mile (RM) 207.2 approximately 0.9 miles downstream from Stevens Creek Dam. The project impounds 190 surface acres at a Normal Pool Elevation of 160 ft AMSL. The dam operates in a run-of-river mode, with no usable storage capacity.

2.5.3 *Sibley Mill Project (Augusta Canal Authority.)*

The 2.457 MW Sibley Mill Project (FERC No. 5044) is located on the Augusta Canal approximately five miles downstream from the Augusta Diversion Dam in Richmond County, Georgia. The current license expires on October 31, 2055. Originally constructed in 1880, the project was converted from hydro-mechanical to hydroelectric power near the turn of the 20th Century. There is no dam or impoundment associated with the Sibley Mill Project. The project is owned and operated by the Augusta Canal Authority and withdraws up to 1,024 cfs of water from the Augusta Canal for discharge into an open concrete canal that flows into the Savannah River.

2.5.4 *Enterprise Mill Project (Melaver/Enterprise Mill, LLC)*

The 1.2 MW Enterprise Mill Project (FERC No. 2935) is located on the Augusta Canal approximately 0.5 miles downstream from the Sibley Mill Project in Richmond County, Georgia. The current license expires on October 31, 2055. There is no dam associated with the Enterprise Mill Project. The project operates in a run-of-river mode and withdraws approximately 560 cfs of water from the Augusta Canal when running at full capacity. Construction of the Enterprise Mill commenced in 1845 and was expanded in 1875. The existing turbines were installed in 1920. The Augusta Canal Authority operates the Enterprise Mill Project under an agreement with Melaver/Enterprise Mill, LLC.

2.5.5 *King Mill Project (Augusta Canal Authority.)*

The 2.25 MW King Mill Project (FERC No. 9988) is located on the Augusta Canal approximately 5.5 miles downstream from the Augusta Diversion Dam in Richmond County, Georgia. An application for a new license was filed with the FERC on May 1, 2007, and a 43-year, 4-month license (expiring on October 31, 2055) was issued effective August 3, 2012. The term of the new license was set to coincide with the FERC license expiration dates for the Sibley Mill and Enterprise Mill Projects.

There is no dam or impoundment associated with the King Mill Project. There are two generating units and approximately 881 cfs of water is withdrawn from the Augusta Canal when operating at full capacity. All flows return to the Savannah River approximately 5.5 miles downstream from the diversion dam. The King Mill Project is owned by the Augusta Canal Authority, but operated by Standard Textile Augusta Inc. Operations at the King Mill Project vary on a day-to-day basis, depending on the gravity flow and water levels of both the Augusta Canal and the Savannah River.

2.5.6 *Urquhart Station Project (South Carolina Electric & Gas Company)*

The 650 MW Urquhart Station Project is a five-unit coal and natural gas-fired power station located at Beach Island on the Savannah River near Augusta in Aiken County, South Carolina. The Urquhart Station Project began commercial operation in 1953 with two 75 MW units and one 100 MW unit. In 2002, two of the coal-fired units were converted to combined-cycle units fueled by natural gas. The project also has 50 MW of combustion turbine capacity. The project is operated by SCE&G.

2.5.7 *New Savannah Bluff Lock and Dam Project*

The NSBL&D Project is located approximately 33 miles downstream from the JST Dam and approximately 13 miles downstream from Augusta (Richmond County), Georgia and North Augusta (Aiken County), South Carolina. The NSBL&D Project consists of a lock chamber, operation building, and a 50-acre park and recreation area. The Project is no longer used for commercial navigation. The park is operated by the Augusta/Richmond County under a lease from USACE.

USACE has committed to construct a fish bypass at the NSBL&D as one of the mitigation features in the Savannah Harbor Expansion Project. The bypass design in the 2012 Final Environmental Impact Statement would pass river flows up to 8,000 cfs around the South Carolina side of the lock and dam. Flows over that amount would pass through the existing gates on the dam.

2.5.8 *Alvin W. Vogtle Nuclear Power Plant (Southern Nuclear Operating Company-Operator)*

The 2,400 MW Alvin W. Vogtle Nuclear Power Plant is located along the Savannah River in Burke County, Georgia. The facility has two pressurized water reactors. Units 1 and 2 began commercial operation in 1987 and 1989, respectively. Cooling water requires the withdrawal of an average of 62 MGD (maximum of 74 MGD maximum) from the river. On August 15, 2006, Southern Nuclear formally applied for an Early Site Permit (ESP) for two additional units at the facility. In March 2008, Southern Nuclear filed a Combined Construction and Operating License (COL) application with the NRC for new units at the facility. In February 2012, the NRC approved the application for Vogtle Units 3 and 4. Commercial operation of the additional units is expected to begin in 2017 and 2018, respectively. Cooling for the two additional units would require withdrawal of an additional 74 MGD (maximum) from the river. GA DNR-EPD recently announced its intent to grant a water withdrawal permit for that additional withdrawal.

2.5.9 *McIntosh Steam Plant (Southern Company)*

McIntosh Steam Plant (also known as Effingham Steam Plant) is a 178 MW coal-fired power plant located in the City of Rincon, (Effingham County) Georgia. The plant began commercial operation in 1979.

2.5.10 *Plant Kraft (Southern Company/Savannah Electric and Power Company)*

Plant Kraft is a 208 MW coal-fired facility located along the Savannah River in Port Wentworth, Chatham County, Georgia. The plant has three units: Unit 1 (50 MW) was placed in service in 1958, followed by Unit 2 (54 MW) in 1961, and Unit 3 (104 MW) in 1965.

2.6 Water Supply

Water users in the Savannah River Basin that currently withdraw from, or return to, surface waters at an average rate of 0.1 million gallons per day (mgd) or greater are classified based on the following categories (information sources include SC DHEC and the Georgia Department of Natural Resources [GA DNR]):

- Public Water/Wastewater Utility
- Industrial
- Power
- Agricultural/Irrigation

Table 2.6-1 provides the number of Savannah River Basin water users identified by category and the estimated aggregate water use for 2010. The 2010 values are used as the current water use data since this data represents the most accessible and reliable water use information (HDR

2012). Table 2.6-2 presents future projected water use for 2066 from the Savannah River Basin. In order to develop reliable water withdrawal and return projections, users that withdraw or return from a surface water source an average daily rate of at least 100,000 gallons per day (or 0.1 mgd) from each reservoir watershed were included in the water supply analysis. Variations in total number of users from current to future values may be attributed to projected permit expirations, utility consolidations, and/or ownership changes.

Table 2.6-1 Savannah River Basin Current Water Use Information

Category	2010 Withdrawals		2010 Returns		2010 Net Withdrawals
	No.	Rate (mgd)	No.	Rate (mgd)	Rate (mgd)
Public Water/Wastewater Utility	35	201 (311 cfs)	54	108 (167 cfs)	93 (144 cfs)
Industrial	15	105 (162 cfs)	36	145 (225cfs)	-40 (-62 cfs)
Power	9	128 (199 cfs)	N/A[1]	N/A[1]	128 (199 cfs)
Agricultural/Irrigation Demand	N/A[2]	62 (96 cfs)	N/A[2]	N/A[3]	62 (96 cfs)
Total	59	496 (768 cfs)	90	253 (392 cfs)	243 (376 cfs)

Notes:
[1] Power withdrawals are net withdrawals (i.e., returns are accounted for in these values).
[2] Current agricultural/irrigation water use based on U.S. Geological Survey (USGS) data, which is aggregated by county.
[3] Agricultural/irrigation water use is assumed to be completely consumptive (i.e., no returns).

Table 2.6-2 Savannah River Basin Future Projected Water Use Information

Category	2066 Withdrawals		2066 Returns		2066 Net Withdrawals
	No.	Rate (mgd)	No.	Rate (mgd)	Rate (mgd)
Public Water/Wastewater Utility	34	511 (790 cfs)	54	223 (345 cfs)	288 (445 cfs)
Industrial	30	131 (203 cfs)	36	193 (299 cfs)	-62 (-96 cfs)
Power	20	305 (471 cfs)	N/A[1]	N/A[1]	305 (471 cfs)
Agricultural/Irrigation Demand	N/A[2]	62 (96 cfs)	N/A[2]	N/A[3]	62 (96 cfs)
Total	84	1,008 (1,560 cfs)	90	416 (644 cfs)	592 (916 cfs)

Notes:
[1] Power withdrawals are net withdrawals (i.e., returns are accounted for in these values).
[2] Projected agricultural/irrigation water use based on USGS data, which is aggregated by county.
[3] Agricultural/irrigation water use is assumed to be completely consumptive (i.e., no returns).

2.6.1 *Lake Jocassee*

There are no consumptive water withdrawals located on Lake Jocassee. The potential for future population growth around Lake Jocassee is limited due to its location in the Nantahala and Sumter National Forests, and the proximity of state parks and state-owned conservation land to the reservoir.

2.6.2 *Lake Keowee*

There are currently two municipal water withdrawal intakes on Lake Keowee: Greenville Water and Seneca Light & Water (Seneca). The area surrounding Lake Keowee has a moderate to high potential for residential growth, particularly to the south and southwest. Further, the area around the City of Greenville, South Carolina, which uses drinking water withdrawn from Lake Keowee, continues to grow. Given that the area around the Keowee-Toxaway Project continues to attract new development, Duke Energy anticipates the demand for water to support municipalities will continue to increase in the future. In addition, Duke Energy's ONS also withdraws water from Lake Keowee for cooling purposes.

The current (based on 2010 data) total water withdrawal from Lake Keowee is 65.6 mgd (101.5 cfs). Municipal and agricultural withdrawals account for 41.2 mgd (63.7 cfs) and net evaporative water use due to thermal cooling at ONS accounts for 24.5 mgd (37.9 cfs). Current total water returns in Lake Keowee are 1.5 mgd (2.4 cfs) from municipal sources (HDR 2012).

2.6.3 *Hartwell Lake*

Current total water withdrawals from Hartwell Lake and tributaries to Hartwell Lake (based on 2010 data) are 39.0 mgd (60.3 cfs), including withdrawals from ten municipal (public) raw water intakes. Current total water returns are 14.6 mgd (22.6 cfs). Hartwell Lake has three users holding water storage contracts that allow a total withdrawal of 26,574 ac-ft (or 53 percent) of the available 50,000 ac-ft of water supply storage authorized by Congress. These users are Lavonia, Georgia; Hart County, Georgia; and Anderson County, South Carolina.

USACE manages the amount of water that can be reallocated based on storage (in ac-ft) rather than yield (i.e., a particular withdrawal rate). As a result, the user (e.g., industry or municipality) must request a permanent reallocation of storage (in ac-ft) to support a given flow requirement (in cfs). The storage to support a particular yield is based on the drought of record at the time of the request. Based on the minimum reservoir levels that occurred during the 2007 through 2009 period, the USACE has deemed this period to be the worst drought on record. If a more severe drought occurs in the future, additional storage may need to be purchased (if available) to support the desired yield. The remaining storage at Hartwell Lake available for reallocation to water supply purposes is 23,426 ac-ft.

The permanent reallocation agreement is similar to a bank account of water that is debited by the user and credited based on a pro-rated apportionment of inflow coming into the reservoir. Debits and credits are determined on the first day of each month for the prior month. The amount of inflow coming into the reservoir is based on the net change in reservoir storage during the previous month plus the amount withdrawn by all users during the previous month (users must submit a monthly report to the USACE documenting their withdrawals). Debits for the prior month only occur if the reservoir the withdrawal is being made from is below guide curve on the first day of the current month.

During conservation operations (i.e., when the reservoir is below guide curve), USACE tracks each user's account on a monthly basis. The bank account of water is reset to the full reallocation purchased when the reservoir returns to guide curve, and is determined on the first day of each month.

2.6.4 *RBR Lake*

Current total water withdrawals from the RBR watershed (based on 2010 data) are 6.6 mgd (10.2 cfs), including withdrawals from two municipal raw water intakes. Current total water returns are 10.1 mgd (15.6 cfs) (HDR 2012). RBR Lake has the smallest discretionary limit for storage reallocations at 9,300 ac-ft. Water storage contracts for RBR Lake include Abbeville, Elberton, Georgia and Santee Cooper. These users account for 872 ac-ft (9 percent), leaving 8,428 ac-ft of the authorized storage reallocation.

2.6.5 *J. Strom Thurmond Reservoir*

Current total water withdrawals from the J. Strom Thurmond Reservoir (based on 2010 data) are 22.2 mgd (34.3 cfs), including withdrawals from eleven municipal raw water intakes. Current total water returns are 4.7 mgd (7.3 cfs) (HDR 2012). There are five users with permanent water storage contracts withdrawing from JST Lake: McCormick, South Carolina; Lincolnton, Georgia; Thomson, Georgia; Columbia County, Georgia; and Washington, Georgia. Of the 50,000 available ac-ft, these users account for 3,833 ac-ft (approximately 8 percent), leaving 46,167 ac-ft of the remaining available storage reallocation at JST.

2.6.6 *Lower Savannah River Basin*

Sixteen major municipal water withdrawal intakes are located downstream of JST Dam (USACE 2008a). The major municipal users extend from Augusta, Georgia, downstream to the coast at Savannah Harbor. The City of Augusta, Georgia withdraws water from the Augusta Canal (USACE 2008a). The City of North Augusta, South Carolina withdraws water from the pool upstream of the NSBL&D (RM 187.5) (USACE 2008a). The Beaufort-Jasper County Water Supply Authority withdraws water at RM 39.3. The City of Savannah’s M&I Plant is located on Abercorn Creek, at approximately RM 29. The other major municipal users consist of Columbia County, Georgia and Edgefield County, South Carolina (USACE 2008a).

Industrial users with intakes in the NSBL&D pool include North Augusta, Mason’s Sod, Kimberly Clark, Urquhart Station, PCS Nitrogen, Demand Side Management (DSM) Chemical and General Chemical, and SCE&G (USACE 2008a). Additional users downstream of NSBL&D include International Paper, Savannah River Site, Vogtle Nuclear Power Plant, Savannah Electric, Georgia-Pacific, and the Savannah National Wildlife Refuge (USACE 2008a). The total withdrawals in this area downstream of JST Dam are 363.6 mgd (562.5 cfs) and the total returns are 227.6 mgd (352.1 cfs) (HDR 2012).

2.7 Water Quality Standards

The Savannah River Basin is located within North Carolina, South Carolina, and Georgia. Most large headwater streams entering Lake Jocassee originate in North Carolina; all streams and rivers entering Lake Keowee fall under the jurisdiction of South Carolina. Both North and South Carolina have assigned state water quality standards commensurate with a designated use of a waterbody. Georgia classifies the waters of the state by designated use and has assigned water quality standards to each use classification.

North Carolina, South Carolina, and Georgia have similar categories of designated use; however, variations or sub-sets of general classifications differ between the states. Even though specific designations differ between the states, the states have distinguished between general use to maintain and support aquatic life and general contact recreation, trout habitats, and high value resource areas. Water use classifications and water quality standards for all three states are described in Appendix C.

2.7.1 *Duke Energy Projects*

Duke Energy monitored water quality after impoundment of Lakes Jocassee and Keowee, as required by the Atomic Energy Commission (AEC-predecessor to the NRC) for the licensing of ONS. This initial monitoring has continued with minor modifications.

Prior to 1981, ONS's thermal discharge was permitted under the authority of the NRC. Since that time, the ONS thermal discharge has been permitted under the National Pollutant Discharge Elimination System (NPDES) as authorized by SC DHEC. Pursuant to the Clean Water Act Section 316(a), three demonstrations have been successfully submitted to SC DHEC. The majority of the water quality data collected by Duke Energy on Lake Keowee, and presented in this document, was in support of ONS permitting. Details of Lake Keowee water quality sampling, water quality data analysis, and impact of once-through-cooling water in Lake Keowee are presented in the three Clean Water Act Section 316(a) demonstrations (Duke Power Company 1995 and Duke Energy 2007 and 2012).

Duke Energy water quality sampling on Lakes Jocassee and Keowee generally consisted of monthly[4] in situ sample collection for analysis of temperature, dissolved oxygen (DO), conductivity, and hydrogen ion concentration (pH) at several locations (Figures 2.7-1 and 2.7-2). This water quality monitoring program was designed to determine long-term water quality trends. Additionally, water samples were also collected at least semi-annually for analysis of nutrients, chlorophyll a, and primary anions and cations as well as various metals.

Various governmental agencies have also conducted water quality assessments of Lakes Jocassee and Keowee. The U.S. Environmental Protection Agency (EPA) conducted water quality surveys on Lake Keowee as part of the National Eutrophication Survey (US EPA 1975). EPA found Lake Keowee was mesotrophic and ranked it first in overall water quality compared to other South Carolina reservoirs.

The U.S. Fish and Wildlife Service (USFWS) (Oliver and Hudson 1987) conducted monthly temperature and oxygen profiling at 13 locations in Lake Keowee from 1971 to December 1982. The depression of the thermocline, expansion of the epilimnion, and increased vertical mixing of D.O. throughout the reservoir was the result of ONS pumping deep, cool water for condenser cooling from under a 67-foot deep skimmer wall. In addition, the USFWS noted a cold water plume in the northern portion of Lake Keowee as a result of Jocassee operations.

SC DHEC has consistently identified Lakes Jocassee and Keowee as among the cleanest South Carolina reservoirs based on 1980–1981, 1985–1986, and 1989–1990 data. DHEC has placed both reservoirs in the highest water quality classification and recommended preservation of existing conditions. Water quality in Lake Keowee is second only to Lake Jocassee, which DHEC considered excellent.

[4] Quarterly sampling occurred from 1984 to 1987.

Figure 2.7-1 Water Quality Monitoring Sites – Jocassee Watershed

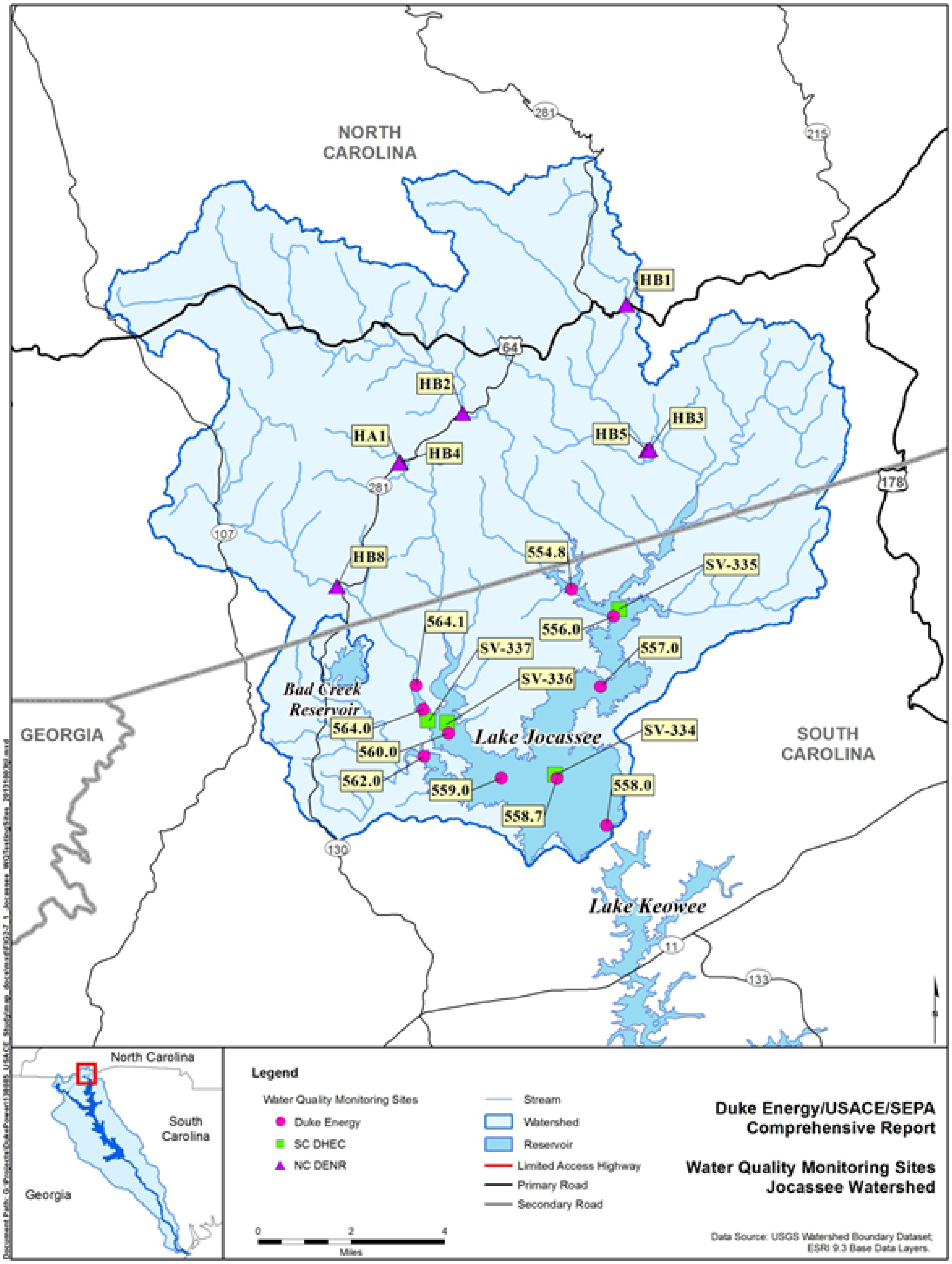
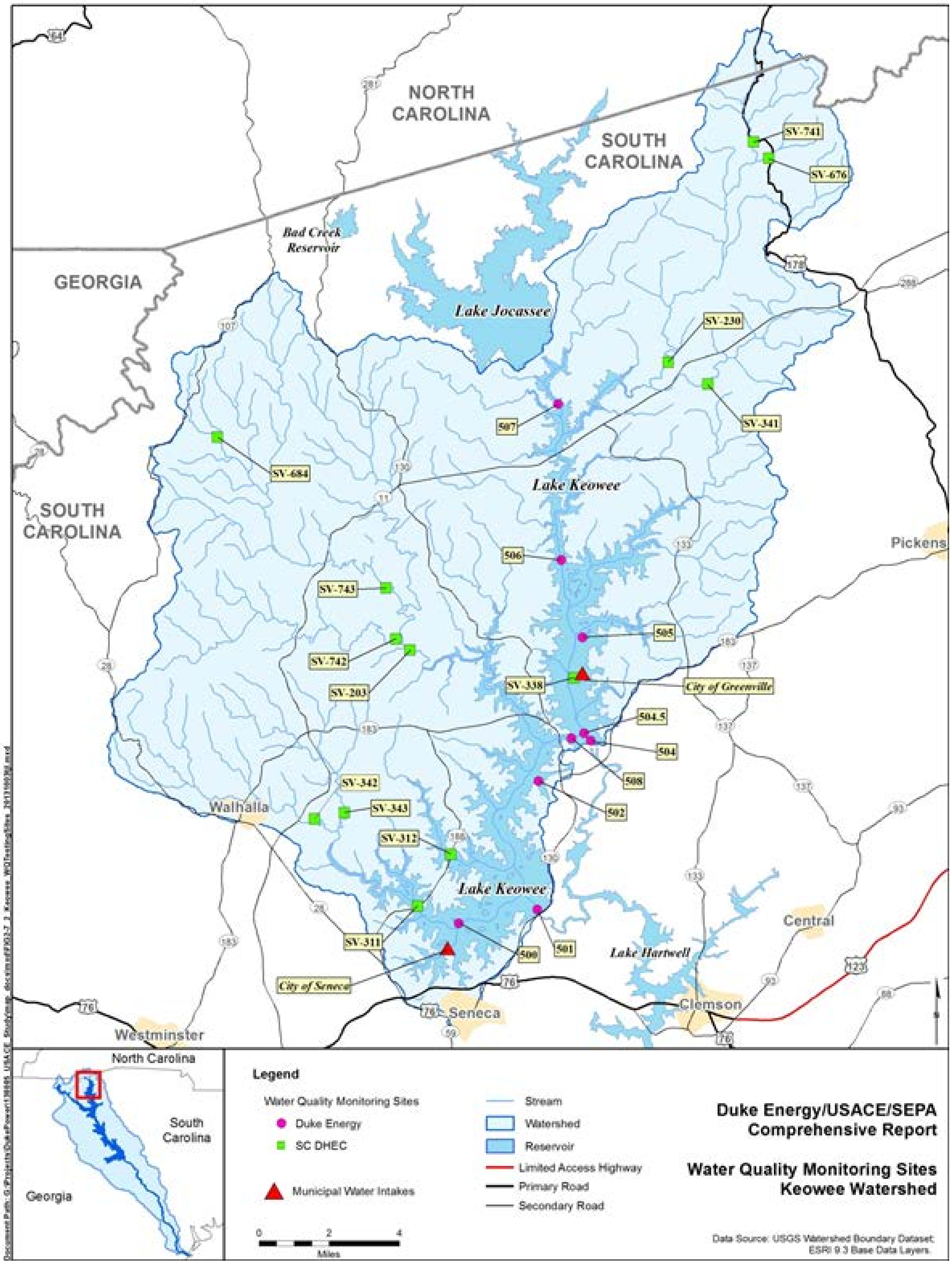


Figure 2.7-2 Water Quality Monitoring Sites – Keowee Watershed



2.7.1.1 *Lake Jocassee*

Lake Jocassee is one of only a few reservoirs in South Carolina that possesses the necessary combination of water temperatures and D.O. levels to ensure the survival of salmonid (trout) species year-round. Following impoundment of Lake Jocassee in the early 1970s, state fishery biologists from South Carolina introduced both rainbow and brown trout into the reservoir to diversify its fishery. The stocking of rainbow and brown trout has continued annually to present day, resulting in a productive combination of various gamefish for the avid fishery sportsman. Continued success of the trout fishery depends partly on the year-round availability of suitable pelagic habitat, as defined by specific thermal and D.O. limits.

Over the history of Jocassee Pumped Storage Station operations, the reservoir has experienced drawdowns of up to approximately 29 feet. Temperature and D.O. distributions within the reservoir during these large drawdown events have been compared to full pool and an intermediate level. The results of this comparison indicated that low water years exhibited deeper, stronger thermoclines. However, the overall thermal structure of the reservoir was maintained and D.O. concentrations throughout the water column were not impacted by the reduction of reservoir elevation. Rather, D.O. concentrations were primarily a function of the degree of the previous winter mixing. Colder winter temperatures resulted in deeper mixing within the reservoir, which in turn resulted in higher D.O. concentrations the following year (and vice versa).

In 2008, Duke Energy installed a water quality monitor to collect continuous temperature, D.O., conductivity, and water level data in the Jocassee tailwater area (i.e., upper end of Lake Keowee). Data from this monitoring location indicate that, as expected, Jocassee Pumped Storage Station releases cool water from deeper in the reservoir compared to the warmer surface water withdrawal at Keowee Hydroelectric Station. D.O. concentrations in the Jocassee tailwater area reflect the oxygen concentrations at the withdrawal depth and are relatively consistent given the relatively high exchange rates of similar water between the forebay and tailrace during generating and pumping cycles. During April to October 2012, temperature and D.O. data were collected in both the forebay and tailwater areas to evaluate the effects of Jocassee Pumped Storage Station operations on water quality. Throughout the 2008 - 2012 study period, D.O. and temperature from the forebay and the tailwater monitoring locations were similar, and both locations had higher D.O. levels than state water quality standards (up to 9 mg/L compared to the state standard of 5 mg/L). Details of the 2012 study are provided in Appendix C.

2.7.1.2 *Lake Keowee*

Unlike Lake Jocassee, Lake Keowee is a typical Southeastern monomictic reservoir with one stratified period and a long, fall-winter mixing period. Rather than having a single basin like Lake Jocassee, Lake Keowee has two basins (the Keowee Basin and the Little River Basin) connected by a man-made canal. Although connected, each basin exhibits slightly different patterns of temperature and oxygen stratification.

The seasonal patterns of temperature and D.O. in the two basins of Lake Keowee reflect similar heating and cooling with respect to the local seasonal patterns of meteorology, namely as the weather cools in the fall-winter period, heat is lost from the reservoir with the coolest reservoir temperatures observed in February and March. Unlike Lake Jocassee, both basins forming Lake Keowee mix completely every year (related to the relative shallow depth of Lake Keowee as compared to Lake Jocassee) and, consequently, Lake Keowee re-aerates every winter.

The Keowee Basin exhibited similar seasonal trends of temperature and D.O. changes as the Little River Basin. However, rather than developing one thermocline, two temperature gradients were observed, one at the depth of the Jocassee Pumped Storage Station pump-back intake and the other at the same depth as the Little River Basin. This pattern of stratification suggests that as Jocassee Pumped Storage Station releases water into the Keowee Basin, the cooler water (relative to the surface of Lake Keowee) from Lake Jocassee plunges to a depth commensurate with the water density of the cool water. Conversely, during the times of Jocassee Pumped Storage Station pump-back, warmer surface water from Lake Keowee is withdrawn from Keowee Basin and pumped into Lake Jocassee, thereby strengthening and maintaining the temperature gradient observed in Lake Jocassee. Even though the winter mixing re-established the initial temperature and oxygen conditions for the upcoming stratification period, the winter conditions, unlike Lake Jocassee, did not pre-determine hypolimnetic conditions at the height of stratification in Lake Keowee.

Duke Energy has monitored temperatures in the Keowee Hydroelectric Station forebay and tailrace on a daily basis since 2000. In 2008, Duke Energy installed a water quality monitor to collect water temperature, D.O., conductivity, and water level data in the tailrace area. The Keowee tailrace temperatures are indicative of the surface water withdrawal, but never exceeded 90ºF. Because Keowee Hydroelectric Station releases water at infrequent intervals (as compared to Jocassee Pumped Storage Station operations), there is greater variability in temperature and D.O. concentrations in the tailrace during these flow releases. The D.O. concentrations in the water released from Keowee Hydroelectric Station were above state water quality standards at all times. Details of this analysis are provided in Appendix C.

2.7.2 ***USACE Projects***

USACE conducts water quality monitoring on the Hartwell, RBR, and JST Reservoirs. The primary objectives of the monitoring program are to document water quality conditions (particularly temperature and D.O.) with emphasis on the influence of its operations (hydroelectric generation, pumped storage operations, and operation of oxygenation systems) on water quality. Past studies have examined reservoir and tailrace conditions in all three reservoirs. The current monitoring program does not include water quality sampling in Hartwell Lake, but data are still being collected in the Hartwell Project tailwater area.

Generally, water quality in the USACE Reservoirs meets or exceeds applicable state water quality standards. Similar to Duke Energy’s Lake Jocassee and Lake Keowee, the USACE Reservoirs experience thermal stratification during the late spring to late fall months. As a result, reservoir temperatures and D.O. concentrations are the primary water quality constituents of concern pertaining to this study.

2.7.2.1 *Hartwell Lake*

Thermal stratification begins in Hartwell Lake in late April and early May of each year. The thermocline is established at a depth of about 30 feet and is maintained at that depth through early August. The thermocline moves to a depth of about 40 feet in late August and early September and to about 50 feet in late September and early October. By late October or early November, Hartwell Lake starts to destratify due to cooler air temperatures and the thermocline moves to a depth of about 70 feet. Isothermal conditions exist by early December each year (USACE 1995).

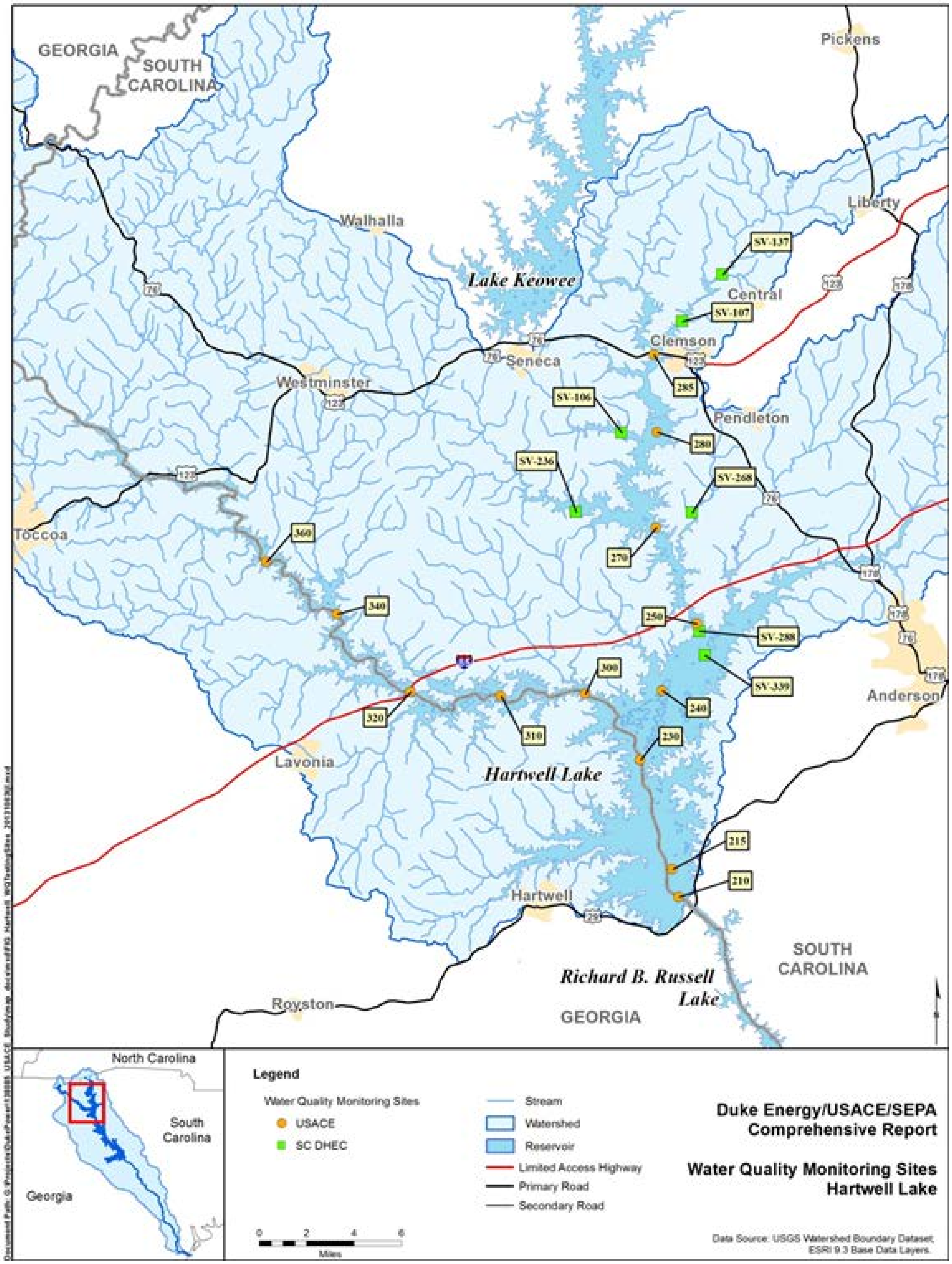
During stratified conditions, the D.O. in the epilimnion remains at a relatively constant concentration around 7 milligrams per liter (mg/L) while D.O. concentrations in the hypolimnion are much lower. The level of the maximum D.O. concentration gradient is established at a depth of about 30 feet in July, it moves to a depth of about 40 feet in August, and then it moves to a depth of 55 or 60 feet by late September. In early August, there is usually a 3 mg/L difference in D.O. levels between the upper and lower layers. By the middle of September, the D.O. in the hypolimnion can range between 0 and 2 mg/L. The water quality of the lower layer continues to deteriorate until the fall overturn occurs. As the water column destratifies, the level of the maximum D.O. concentration gradient falls to 80 feet in October and near the reservoir bottom in early December, after which the D.O. concentration is nearly the same at all levels until the following spring (USACE 1995). D.O. concentrations of water released from Hartwell Lake can be below 5 mg/L from late summer through early fall, with the lowest readings from August through September (USACE 2008a).

Based on the 1991–1992 comprehensive sampling study of Hartwell Lake, temporal and spatial gradients in D.O. were noted from the dam to the headwaters of both main embayments, particularly during the stratified period. Anoxic conditions were greater in the Seneca River arm than in the Tugaloo River arm potentially due to an increased amount of nutrients from greater organic material. Oxygen depletion was first observed in the mid reaches of both embayments in June. By early September, anoxic conditions were present and lasted until mid-October when re-aeration of the hypolimnion had occurred in both arms of the reservoir. Anoxic depletion in the upstream embayments was likely due to the summer flow releases from Hartwell Dam (Jabour 1993).

Since 2006, temperature, D.O., and specific conductance have been monitored continuously inside the penstock (upstream from the turbines) and in the immediate tailrace area. In general, tailrace D.O. concentrations are approximately 1.2 mg/L higher than the penstock D.O. concentrations. The increase in D.O. is the result of turbine venting and other reaeration effects in the tailrace area (USACE 2011). During the January through August 2009 monitoring period, penstock D.O. concentrations dropped below 5 mg/L in August, but tailrace D.O. concentrations remained above 5 mg/L. Monthly mean temperatures in the Hartwell Project tailrace ranged from 48ºF to 55ºF during the January through August 2009 monitoring period.

The 2012 South Carolina Section 303(d) list of impaired waters includes three locations in Hartwell Lake (Twelve-Mile Creek, Coneross Creek, and Lake Hartwell Dam area) that are listed as impaired for fish consumption due to high levels of polychlorinated biphenyls (PCBs) as well as two locations listed as impaired for aquatic life use due to the levels of total nitrogen, total phosphorus, and turbidity (Eighteen-Mile Creek) or pH (Lake Hartwell near Anderson City) (SC DHEC 2012). PCB levels have been elevated in the Eighteen-Mile Creek area as a result of contamination from an industrial site on the river, resulting in its designation as an EPA Superfund site. Work is presently underway to restore natural flows in that river to improve that environment.

Figure 2.7-3 Water Quality Monitoring Sites – Hartwell Lake



2.7.2.2 *RBR Lake*

RBR Lake backs up close to the tailwater of Hartwell Lake. As a result, water released from Hartwell Dam can affect water quality in RBR Lake, particularly during the summer months when low D.O. water can be released into the upper end of RBR Lake. From 1984 to 1988, a water quality sampling program was undertaken in RBR Lake to evaluate the impacts of project operations on water quality in the reservoir and immediate tailrace area.

During the 1984 to 1988 monitoring period, spatial patterns in thermal gradients were observed along the mainstem of the reservoir and thermal stratification was present from the dam to the headwaters. Stratification was evident in late March and a well-developed thermocline was present near a depth of 20 feet in mid-May. The thermocline remained between 20 and 26 feet and temperatures ranged from 53.6 to 82.4°F during the summer stratification period. The thermocline began to weaken with seasonal cooling in late-September to early-October and complete mixing was observed in late-October. Thermal regimes in the mainstem of the reservoir can be affected by the flows released from Hartwell Lake.

Temporal and spatial gradients in D.O. were apparent along the mainstem of the reservoir during stratification. Concentrations ranged from 8 to 10 mg/L in the epilimnion and gradually decreased in the hypolimnion. D.O. concentrations were higher at the surface (4 mg/L) in the mainstem and throughout the water column in the mid to upper stream region of the mainstem. Anoxic conditions were confined to the bottom waters and were established by mid-June. The anoxic conditions remained in the bottom 20 to 33 feet of the downstream end of the reservoir.

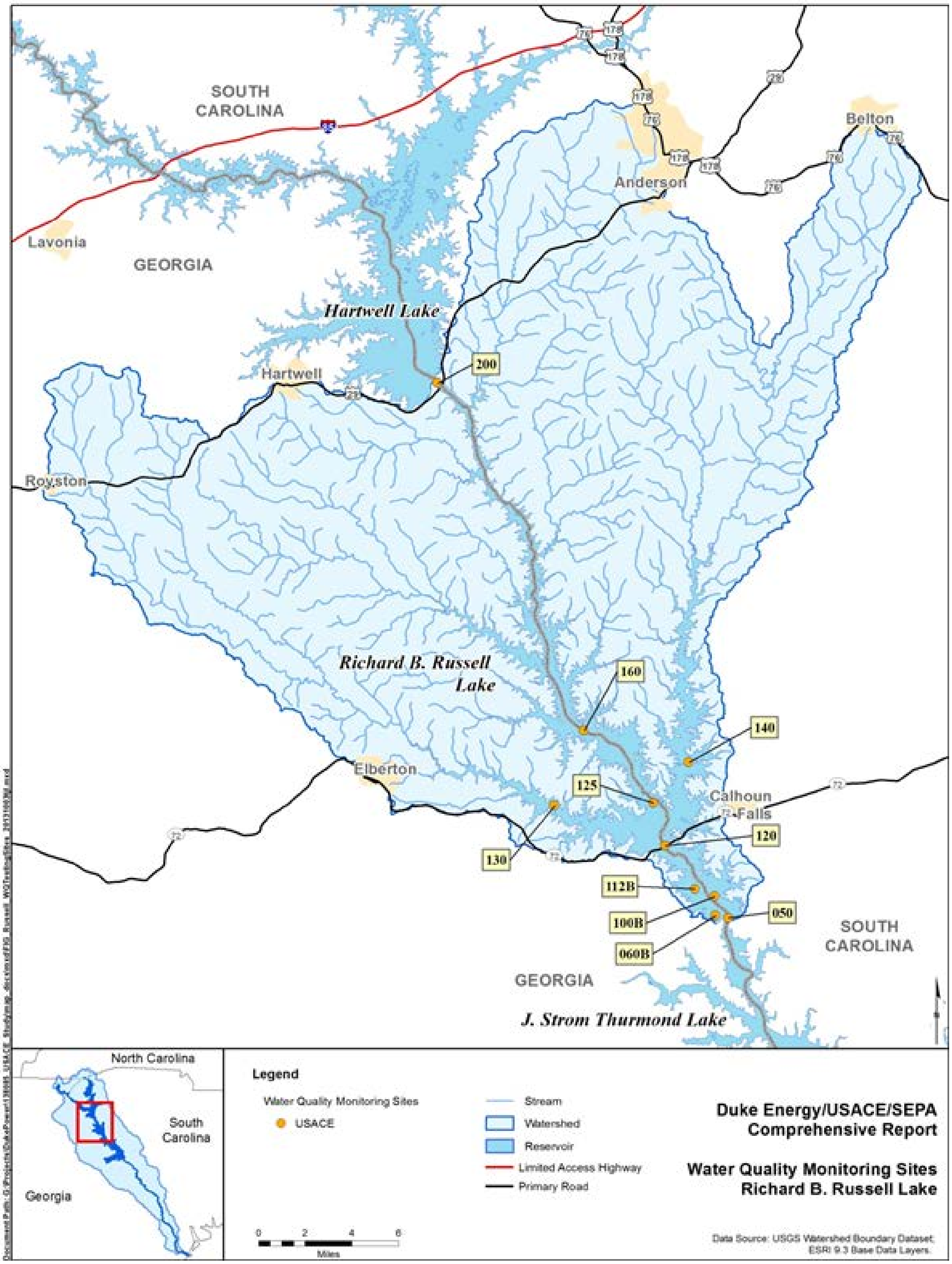
In 1988, the USACE began using a hypolimnetic oxygen injection system just upstream of the RBR Dam. Both the continuous and pulse injection systems operated during the stratified period with a combined capacity of 65 tons of oxygen per day. Delivery rates decrease as stratification decreases and typically end in early-November. This system is able to maintain the concentrations of D.O. near 6 mg/L at most depths in the forebay and within the turbine discharges. Concentrations below 6 mg/L have been noted in the RBR forebay at depths below 35 meters (m) (Ashby et al. 1994). Temperature and D.O. concentrations in the water discharges showed similar trends to those of the forebay. D.O. concentrations correlated with the operation of the oxygenation system and gradually returned to 8-12 mg/L during November and December (Ashby et al. 1994).

Beginning in 2006, the USACE's Engineer Research and Development Center (ERDC) monitored designated stations along the mainstem and major tributary embayments in RBR Lake (Figure 2.7-4). In situ measurements of temperature, D.O., and specific conductance are obtained monthly at these stations. The vertical and longitudinal patterns of temperature and D.O. in RBR Lake show substantial year-to-year and seasonal variation driven in large part by the volume of water flowing through the system (which in turn influences the volume of pumped storage in RBR Lake) and the seasonal patterns of vertical stratification (USACE 2009).

In addition to the monthly sampling program, temperature and D.O. are monitored continuously in the RBR Project penstock and immediate tailrace area (Station 050 on Figure 2.7-4) to determine when to operate the oxygen injection system. The oxygen injection system operates when low D.O. conditions are present. During 2009, the oxygen injection system ran the second half of June (average injection rate of 8 tons/day), the second half of July (average injection rate of 13 tons/day), and all of August (average injection rate of 26 tons/day). D.O. concentrations in the RBR discharges averaged 5.2 mg/L during the July through August 2009 period of system operation (USACE 2009).

The 2012 South Carolina Section 303(d) list of impaired waters includes three locations in RBR Lake listed as impaired for fish consumption due to high levels of mercury. These areas include RBR Lake near South Carolina Highway 181, Van Creek, and near the RBR Dam (SCDHEC 2012).

Figure 2.7-4 Water Quality Monitoring Sites – RBR Lake



2.7.2.3 *JST Lake*

The headwaters of JST Lake back up to the RBR Dam. As a result, water released from RBR Dam affect water quality in JST Lake. From 1984 to 1988, USACE conducted a water quality sampling program in both RBR and JST Lakes to evaluate the impacts of USACE project operations on water quality in the reservoir and immediate tailrace area.

Similar to RBR Lake, the 1984 to 1988 monitoring period showed temporal and spatial patterns in the mainstem of JST Lake with thermal stratification being present up to the headwater regions from April to September. Thermal stratification in the downstream region of the reservoir showed stratification beginning in late-April with the establishment of a thermocline (20-26 ft) in mid-May. Temperatures ranged from 57.2 to 86°F and the thermocline remained near a depth of 26 to 33 feet throughout the stratification period. The thermocline began to weaken in late-September when seasonal cooling began, until the reservoir conditions were almost completely isothermal by mid-October. Temporal regimes in the mainstem can be influenced by flow releases from Hartwell Lake and RBR Lake.

Similarly, temporal and spatial gradients of D.O. were observed in the mainstem of the reservoir during stratification (1984–1988 monitoring period). D.O. concentrations remained near 8 to 10 mg/L, gradually decreasing towards the downstream area of the reservoir. Anoxic conditions were established in the downstream hypolimnion area from mid-to-late August continuing until late October. Anoxic conditions remained within 33 feet of the surface. Concentrations of D.O. did not fall below 4 mg/L in the mid-region of the reservoir. The oxygenated waters during stratification can be attributed to the well-oxygenated flow releases from Hartwell Dam and RBR Dam. Anoxic conditions may also be the result of the proximity of major and secondary tributaries entering JST Lake. Temperature and D.O. concentrations in the water releases showed similar trends to those of the forebay. During fall mixing, D.O. levels were near 10 mg/L in the tailrace (Ashby et al. 1994).

From 2002 through 2007, the turbines at JST Dam were replaced as part of a major rehabilitation effort. The new turbines include a self-aspirating design that is a form of turbine venting. The new turbines now add as much as 3 mg/L of D.O. to the water as they pass through the dam.

Water released from JST Dam has D.O. concentrations of at least 3 mg/L throughout the year (USACE 2008a).

Since 2006, the ERDC has monitored designated stations along the mainstem and major tributary embayments in JST Lake (Figure 2.7-5). In situ measurements of temperature, D.O., and specific conductance are obtained monthly at these stations. Data from these discrete sampling locations is used to estimate the volume of available aquatic habitat on a monthly basis in the reservoir. Similar to RBR Lake, the vertical and longitudinal patterns of temperature and D.O. in JST Lake show substantial year-to-year and seasonal variation, driven in large part by the volume of water flowing through the system and the seasonal patterns of vertical stratification (USACE 2009). July and August are of particular interest in JST Lake because this is the period that puts the most severe limits of temperature and D.O. on habitat for striped bass in the reservoir. Since 2005, the ERDC has made quantitative estimates of available striped bass habitat during the critical summer periods. Minimum habitat typically occurs in July through August and into early-September, with between 20 percent and 40 percent of the reservoir volume categorized as available habitat during low flow years. Conditions improve during the fall, and a majority of the reservoir volume has suitable striped bass habitat by October. August 2007, with relatively low flow conditions, experienced the least available habitat (<20 percent) during the four-year period from 2006 to 2009 (USACE 2009).

In addition to the monthly sampling program, temperature and D.O. are monitored continuously in the JST penstock and immediate tailrace area (Station 10 on Figure 2.7-5) to determine when to operate the turbine venting system. In general, during the summer months, tailrace D.O. concentrations are approximately 2.7 mg/L higher than the penstock D.O. concentrations. During the summer 2009 monitoring period, penstock D.O. concentrations dropped to almost 0 mg/L in August, but tailrace D.O. concentrations remained above 3 mg/L due to the combined effects of turbine venting and other reaeration effects in the tailrace area (USACE 2009).

USACE began construction of an oxygen injection system (similar to the one at RBR Lake) in 2009 and the system began operating in June 2011. Unlike the oxygenation system at RBR Lake, which was designed for pumped storage operations, the system at JST Lake is located in the reservoir approximately 5 miles upstream of the dam. The system was designed to improve D.O. levels in the open waters of the reservoir to make large areas suitable to striped bass. The system has the capability to deliver 200 tons of oxygen per day and the ability to increase D.O. concentrations by an additional 1 to 3 mg/L in the tailrace. USACE operates this system on an as-needed basis during the June through September low D.O. periods. The D.O. concentrations of water released from JST Dam in 2013 are shown in the table below from the 2013 Annual Report of the Southeastern Natural Sciences Academy. The table shows mean monthly D.O. concentrations from JST to Savannah Harbor, with the data for River Mile 215 reflecting the quality of releases from the JST dam. The data shows that in 2013, the mean monthly D.O. levels in JST discharges were generally above 5 mg/l, but got as low as 3.99 mg/L.

Table 6. Monthly mean dissolved oxygen concentration (mg/L).

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RM215	ND	ND	ND	ND	ND	ND	ND	3.99	5.17	5.72	7.96	9.43
RM202	11.13	ND	10.83	10.24	9.50	8.92	8.75	8.59	8.67	8.69	9.59	10.31
RM190	ND	ND	10.77	10.01	9.06	7.98	ND	7.97	7.80	7.77	ND	10.03
Butler Creek	ND	9.97	9.25	7.13	5.91	4.52	4.67	4.77	6.19	7.43	ND	ND
RM148	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RM119	9.69	ND	9.13	7.92	7.50	6.95	5.74	5.95	6.68	7.18	8.20	8.89
RM61	ND	ND	ND	ND	ND	6.44	4.49	4.26	6.38	7.45	8.60	9.29
RM27	9.67	9.66	9.02	7.47	7.18	6.35	4.62	4.21	5.75	7.10	9.03	9.30
RM14	7.74	7.85	7.68	5.64	4.67	3.72	3.86	3.44	4.00	4.67	6.76	7.87

That same report shows D.O. levels at that location throughout 2013 to range as follows:

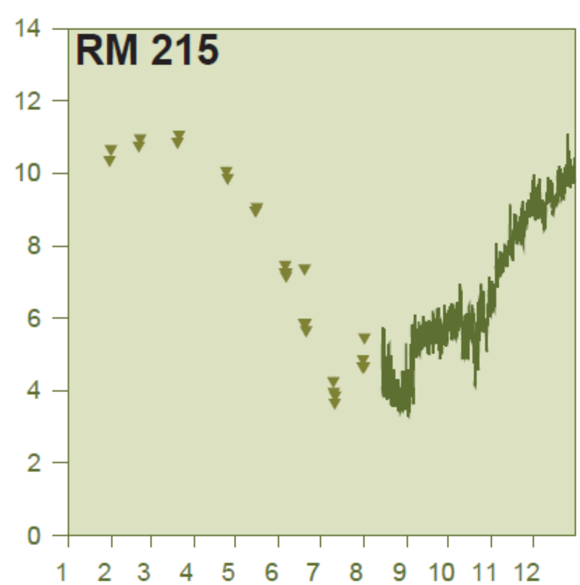
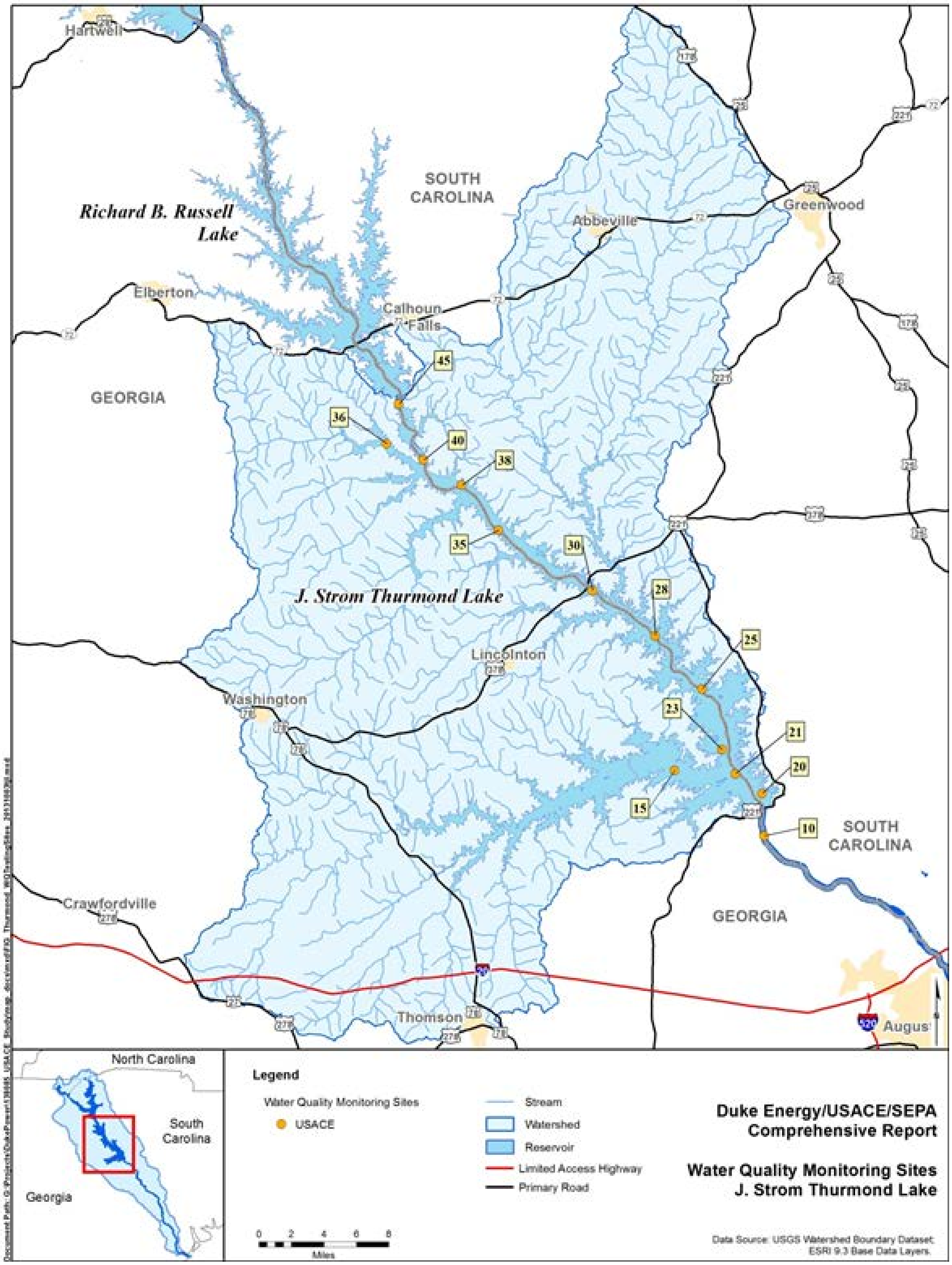


Figure 2.7-5 Water Quality Monitoring Sites – JST Lake



The 2012 South Carolina Section 303(d) list of impaired waters includes one location in JST (Long Cane Creek) that is listed as impaired for fish consumption due to high levels of mercury (SC DHEC 2012). Additionally, the JST Lake headwaters are listed as impaired for fish consumption due to mercury levels.

2.7.3 *Lower Savannah River Basin*

Along the Savannah River, water use classifications consist of Recreation, Drinking Water, and Coastal Fishing. Water use classifications along with the associated water quality standards of the mainstem of the Savannah River downstream of JST Dam are provided in Appendix C.

Portions of the lower Savannah River are listed as impaired on the 2012 Section 303(d) Lists of Impaired Waters for both South Carolina and Georgia. The 2012 South Carolina Section 303(d) list identifies numerous areas along the Savannah River as impaired for fish consumption due to mercury levels and aquatic life use due to turbidity and zinc levels. Reaches of the Savannah River listed as impaired for fish consumption include North Augusta State Park, Jackson Landing, Steel Creek, Little Hell Landing, Cohen's Bluff, Johnson's Landing, Stokes Bluff Landing, B&C Landing, Beck's Ferry, and Millstone Landing. Additionally, the Savannah River off B&C Landing off State Route S 27-201 is listed as impaired for aquatic life use (SC DHEC 2012). The 2012 Georgia 303(d) list includes a 59-mile stretch of the Savannah River from Brier Creek to Ebenezer Creek that is listed as impaired for fish consumption and drinking water due to mercury levels caused by nonpoint sources (GA DNR 2012).

The US EPA has prepared Total Maximum Daily Loads (TMDLs) for portions of the Savannah River as follows:

- Fecal coliform – Savannah River in Richmond County
- Lead – Savannah River between Butler and McBean Creeks
- Oxygen-depleting substances – Savannah River from the Seaboard Coastline Railroad Bridge (RM 27.4) to the coast

Seasonal D.O. sags occur in the summer months in the estuarine portion of the river. US EPA's 2006 TMDL called for zero discharge of oxygen-depleting substances from Augusta to the coast. Their 2010 revised Draft TMDL calls for a 30% reduction in oxygen-depleting substances in that reach. Georgia and South Carolina are working with point source dischargers along the river to develop a protocol to implement that reduction. After EPA finalizes that TMDL, the States will implement the requirements through their point source discharge permitting programs. The recently installed oxygen injection system in the forebay of JST Lake is expected to improve water quality below the JST Dam. Flows immediately below JST Dam are expected to contain at least 5 mg/L of D.O. throughout the year, which would meet both the Georgia and South Carolina standards for D.O.

The State of South Carolina uses the current Drought Plan Level 3 flow of 3,600 cfs (pers. comm., Larry Turner, SC DHEC) at the Savannah River Augusta gage for their wasteload assimilation calculations in permitting point source discharges in the Augusta area DHEC adjusts this flow upward as one moves down the river to account for the additional tributary inputs. The State of Georgia uses the 7Q10 values of 3,800 cfs at the Augusta gage, 4,160 cfs further downstream at the Millhaven U.S. Geological Survey (USGS) flow gaging station, and 4,710 cfs at the Clyo USGS gage in its decisions on the permitting of point source discharges (pers. comm., Paul Lamarre, GA DNR-EPD).

The Port of Savannah is the second-largest container port on the East Coast and the fourth-largest in the country. Savannah Harbor was deepened in the early 1990s and after continued growth in shipping volumes, the Georgia Ports Authority (GPA) requested the USACE conduct a reconnaissance study to determine the need to further deepen the harbor. In 1999, Congress authorized deepening the harbor, subject to some additional studies being conducted. The 2012 Final General Re-Evaluation Report (GRR) and the Final Environmental Impact Statement (FEIS) for the Savannah Harbor Expansion Project addresses the need for navigation improvements to the existing Savannah Harbor Navigation Project, Georgia and South Carolina as authorized by the Water Resources Development Act of 1999 (Public Law 106-53, Section 102(b)(9)). On October 26, 2012, USACE approved the Savannah Harbor Expansion Project via the signed Record of Decision. The Water Resources Reform and Development Act of 2014 (Public Law 113-121) authorized construction of the harbor deepening at a higher project cost.

The FEIS assessed the impacts expected to wetlands, fisheries, benthic communities, birds, marine mammals, endangered species, water quality, cultural resources, historic properties, and other environmental factors for each depth alternative. After avoiding and minimizing impacts where possible, USACE developed a mitigation plan to address the unavoidable adverse impacts to natural resources. The mitigation plan was designed to address both direct impacts to tidal brackish marshes that would occur as a result of dredging and unavoidable indirect impacts such as conversion of tidal freshwater marsh to brackish marsh. It is estimated the lower Savannah River area contains approximately 20 percent of all tidal freshwater marshes in Georgia and South Carolina. Therefore, the USACE considered this an important issue in its evaluation of potential impacts from harbor deepening.

The lower Savannah River estuary has been subjected to number alterations since the 1800s, and when coupled with sea level rise and subsidence, salinity levels have increase in the estuary, causing changes in the distribution of freshwater marsh, brackish marsh, and saltmarsh in the lower estuary.

The USGS report titled "Analysis of the Historical Data for the Lower Savannah River Estuary," contains data from a study conducted from 1990 through 1997. The USGS collected nine months of continuous salinity data from three stations before and after major system alterations. This data was analyzed to determine changes in salinity distribution resulting from these alterations. There were two types of analysis conducted under this study. The first analysis provides general statistical analysis of salinities, tides, and flows for each data period and compares that information with the data gathered post-alteration. This analysis did not account for the seasonal variation of flow and mean water levels.

Table 2.7-1 presents the maximum, mean, and minimum freshwater inflow measured on the Savannah River near Clyo, Georgia (RM 61) and Table 2.7-2 provides changes in Savannah Harbor salinity levels during the same period when system alterations were occurring.

Table 2.7-1 Savannah River Flows near Clyo, Georgia

Flow Statistics from the Savannah River near Clyo USGS Flow Gaging Station (02198500)				
Flow Range	1990	1992	1995	1996
Maximum	17,100 cfs	14,700 cfs	17,000 cfs	13,000 cfs
Mean	8,107 cfs	9,874 cfs	9,774 cfs	9,134 cfs
Minimum	5,700 cfs	6,490 cfs	6,540 cfs	6,760 cfs

Table 2.7-2 Savannah Harbor Salinity Levels

Savannah Harbor Salinity Levels (ppt)				
Port Wentworth, RM 21.7 (USGS 02198920)				
	1990	**1992**	**1995**	**1996**
Mean	1.83	0.58	1.13	1.25
Standard Deviation	1.86	1.16	1.78	2.05
Median	1.22	0.08	0.15	0.19
USFWS Dock, RM 22.0 (USGS 02198997)				
Mean	1.15	0.08	0.08	0.13
Standard Deviation	1.73	0.11	0.10	0.11
Median	0.24	0.05	0.05	0.07
Lucknow Canal, RM 25.36 (USGS 021989784)				
Mean	0.22	0.06	0.08	0.09
Standard Deviation	0.61	0.04	0.04	0.08
Median	0.08	0.05	0.07	0.05

The data between 1990 and 1996 in Table 2.7-2 show a significant change in the salinity conditions after decommissioning of the Tidegate and closure of the New Cut. It is also evident from the data there were minimal impacts from the channel deepening (1992 versus 1995 and 1996). The 0.5 parts per thousand (ppt) contour line is used to determine the threshold salinity value for brackish water. Table 2.7-3 shows the number of salinity events over 0.5 ppt during the alteration periods between June and September of each year.

Table 2.7-3 Occurrences of Salinity Levels >0.5 ppt in the Savannah Harbor

Number of Occurrences of Salinity > 0.5 ppt in the Lower Savannah River by Year and Location					
Location	**River Mile**	**1990**	**1992**	**1995**	**1996**
Port Wentworth (02198920)	21.7	58	25	27	38
USFWS Dock (02198997)	22.0	36	1	1	2
Lucknow Canal (021989784)	25.36	6	0	0	0

A multivariate analysis was developed in an attempt to correlate daily average flow values; daily maximum, mean, and median salinities; daily average mean water levels; and daily maximum tide ranges. In general, individual correlations between the dependent variable salinity and the independent variables showed fair to poor correlations. The best correlations were obtained by using a linear regression model with an independent variable and a one-to four-day lag applied to the flow data from Clyo, Georgia. Results of this analysis showed similar trends as those found in the raw data. For example, saltwater intrusion occurrences decreased 68 percent at Port Wentworth, 93 percent at USFWS Dock, and 73 percent at Lucknow Canal when the Tidegate was decommissioned versus small increases in salinity concentrations associated with deepening the Front River and the Little Back River during 1992 and subsequent years.

In the late 1990s, GPA funded a field monitoring program to document the salinity conditions within the Lower Savannah estuary at that time. A detailed report is provided in the report titled "Hydrodynamic and Water Quality Monitoring of the Lower Savannah River Estuary, July-September 1997." The salinity data were collected as continuous in situ, discrete synoptic, and supplemental marsh data. There were 16 continuous monitoring stations positioned throughout the monitoring area from the Atlantic Ocean at RM -3.5 to the Lucknow Canal at RM 25.3. Surface and bottom concentrations were measured within the navigation channel while those stations outside of the channel recorded near bottom concentrations. The synoptic data was collected at 40 stations which were each monitored for a 12-hour period on August 13, 1997, September 9–10, 1997, and September 30, 1997. The supplemental marsh data was obtained by installing stations within and immediately outside of feeder channels attached to the Front, Middle, and Little Back Rivers, as well as two continuous gages, which recorded salinities entering and leaving the marshes at 15-minute intervals.

Review of historical data determined that subsequent to the decommissioning of the Tidegate, the maximum salinity intrusion along the Front River occurred primarily during neap tide[5] conditions. A possible reason for this is the reduction in velocities along the Front River above Fort Jackson during receding tides. As the tidal effect decreases, the salinity gradient is able to push further upstream. This is because a reduction in the tidal flow correlates to a reduction in turbulent mixing and stronger stratification within the water column. The stronger the stratification, the more the denser salinity is able to move upstream along the bottom of the river. Upstream saltwater intrusion is greatest during neap tide conditions and lowest during stronger spring tide conditions that create more turbulent flow conditions.

2.8 Recreation

During normal operating levels, the reservoirs of the Savannah River Basin provide many opportunities for water-based recreational activities, including boating and swimming. The following subsections provide details on public boat ramps and swimming areas.

2.8.1 *Public Boat-Launching Ramps*

2.8.1.1 *Lakes Jocassee and Keowee*

Duke Energy provides nine public boat ramps on Lake Jocassee and twenty-four on Lake Keowee. On Lake Jocassee, six of the public boat ramps become unusable when reservoir elevations drop 25 ft (1,085 ft AMSL) below a full pool elevation of 1,110 ft AMSL and one boat ramp has recently been extended to accommodate boat launching even if the reservoir is at its maximum drawdown of 30 ft (1,080 ft AMSL). On Lake Keowee, concrete boat ramps begin to become unusable when the reservoir elevation drops approximately nine feet below a full pool elevation of 800 ft AMSL (pers. comm., Scott Jolley, Duke Energy, August 2013). Appendix D provides a detailed list of public boat ramps at Lake Jocassee and Lake Keowee and the reservoir elevation below which ramps may not be usable for most boats. The elevation below which

[5] A neap tide occurs just after the first and third quarters of the moon, when there is the least difference between high tide and low tide.

ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation (pers. comm., Scott Jolley, Duke Energy, October, 2013).

2.8.1.2 *Hartwell Lake*

Hartwell Lake has approximately 111 public boat ramps located at 94 parks and marinas. From an elevation of 660 to 658 ft AMSL, all boat ramps are considered usable. If Hartwell Lake falls below 638 ft AMSL, all boat ramps are considered unusable. Appendix D provides a detailed list of public boat ramp locations (note some locations contain multiple ramps) at Hartwell Lake and the elevation below which ramps may not be usable for most boats. The elevation below which ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation.

2.8.1.3 *RBR Lake*

RBR Lake has approximately 30 public boat ramps and launching sites. All of the sites become unusable at reservoir elevations below 466 ft AMSL. Lake levels typically do not drop more than five feet below the Normal Pool Elevation of 475 ft AMSL; therefore, boat ramps are likely to be usable at all times.

2.8.1.4 *JST Lake*

JST Lake has approximately 100 public boat ramps located at 81 parks and marinas. Boat ramps start to become unusable below a pool elevation of 326 ft AMSL (four feet below full pool of 330 ft AMSL). If JST Lake elevations fall below 306 ft AMSL, all boat ramps are considered unusable. Appendix D provides a detailed list of public boat ramp locations (note some locations contain multiple ramps) at JST Lake and the elevation below which ramps may not be usable for most boats. The elevation below which ramps may not be usable for most boats is presented as two feet above the top of the concrete ramp end elevation. These elevations are based on a comparison of the bottom of ramp elevations with the approximate lake elevation when launching becomes difficult using data available on Savannah District's website for recreation on JST Lake.

2.8.1.5 *Lower Savannah River Basin*

There are approximately 55 public boat ramps with various owners in the Lower Savannah River Basin. Information is not readily available regarding the usability of the boat ramps at different water levels. Based on the location of the majority of the ramps, tidal influences would be the major contributing factor on the usability of these facilities. Appendix D provides a detailed list of the public boat ramps along the Savannah River downstream of JST Lake.

Currently the Augusta Canal prohibits motorized boating and public swimming, but there are several access areas available to canoeists and kayakers. These access areas can be found along a towpath that parallels the canal, starting at the headgates of Savannah Rapids Park and at the Eisenhower/Riverwatch Parkway Bridge. Take-out points are located downstream at Lake Olmstead, Broad Street, and 13th Street. The necessary flow for supporting recreation in the canal is 100 cfs, as shown in Table 2.8-1.

Table 2.8-1 Augusta Canal Recreation Flows

Name of Launch/Take-Out Points	Required Flow Level (cfs)
Manual Launch	
Headgates Savannah Park	100
Riverwatch Parkway Bridge	100
Take-Outs	
Lake Olmstead	100
Broad Street	100
13th Street	100

Source: FERC 2006

2.8.2 ***Swimming***

2.8.2.1 *Lakes Jocassee and Keowee*

Swimming beaches at Lake Keowee are managed as part of the lease agreement Duke Energy has with Oconee and Pickens counties in South Carolina. Reservoir elevations affect the swimming beaches; however, Duke Energy does not decide when these areas are closed based on reservoir elevations. Each county determines when to close a swimming area based on the site's design. Oconee County does not designate any swimming areas at county parks and it does not supply lifeguards or roped off areas, but instead has "swim at your own risk" signage throughout the parks. As a result, there are no designated and managed swimming areas on Lake Jocassee and there are no criteria for swimming areas to be closed based on reservoir elevations. Pickens County has one public swimming area on Lake Keowee, but similar to Oconee County, it has no criteria for this area to be closed based on reservoir elevations.

2.8.2.2 *Hartwell Lake*

The USACE manages 22 swimming areas at 13 recreation areas on Hartwell Lake. When reservoir elevations drop to 657 ft AMSL, the swimming areas become less desirable, according to the USACE (2008a). At reservoir elevations of 654 ft AMSL and lower, all designated swimming areas are dry. When this happens swimming occurs outside of the designated areas, increasing the risk of injuries and fatalities to swimmers (USACE 2008a; USACE 2012a).

2.8.2.3 *RBR Lake*

There are no USACE-operated designated swimming areas on RBR Lake.

2.8.2.4 *JST Lake*

The USACE manages 18 swimming areas on JST Lake. When reservoir elevations drop to 327 ft AMSL, the swimming areas become shallower and less desirable (USACE 2008a). Below reservoir elevations of 324 ft AMSL, all designated swimming areas are dry. When this happens, swimming occurs outside of the designated areas, increasing the risk of injuries and fatalities to swimmers (USACE 2008a; USACE 2012a).

2.9 Biotic Communities

Common names for species are referenced throughout the main body of this EA. Appendix E contains tables that cross-reference the common names and scientific names for each species, as follows:

- Fish species Table E-1
- Aquatic plants Table E-2
- Wetland species Table E-3
- Wildlife species Tables E-4 through E-9

2.9.1 *Fisheries*

2.9.1.1 *Lake Jocassee*

Fishery resources in Lake Jocassee have been monitored since approximately 1974 using a variety of aquatic sampling techniques. In association with littoral fish populations in Lake Jocassee, electrofishing surveys were represented primarily by an assemblage of warmwater fish taxa in addition to the cool water and coldwater taxa. Estimated abundances ranged from 415 to 1,235 fish/3,000 m of shoreline, weighing from 18.9 to 49 kilograms (kg), in the lower reservoir area and from 746 to 1,429 fish/3,000 m of shoreline, weighing from 40.3 to 61.3 kg, in the upper portion of the reservoir. Total numbers of fish collected appeared to be similar in both areas, but total biomass appeared to be somewhat higher in the upper portion of the reservoir than the lower reservoir (Barwick et al. 1995).

In Lake Jocassee, gillnetting has been the primary technique used to sample littoral fish populations (Barwick and Geddings 1986). However, boat-mounted electrofishing (as described below for Lake Keowee) was implemented in 1996 and continues to the present day.

Overall, 26 fish species representing seven families and two hybrid complexes (sunfish and black bass) were collected in these surveys with 18 identical species and both hybrid complexes collected in each upper and lower portion of the reservoir (Barwick et al. 1995).

Littoral fish populations in Lake Jocassee gillnetting surveys were also represented primarily by an assemblage of warmwater fish taxa, but these surveys had higher contributions of both cool water and coldwater taxa than the electrofishing surveys. Common carp, flat bullhead, rainbow trout, brown trout, redeye bass, smallmouth bass, and largemouth bass dominated the catch in the surveys. Except for the rainbow trout and brown trout, which are stocked annually by the SC DNR, all other littoral fish taxa are indigenous or naturalized to the reservoir and are reproducing naturally (Barwick et al. 1995).

The entire reach of the Whitewater River in South Carolina and the Eastatoe Creek and its headwater tributaries (i.e., upstream of Lake Keowee) support an excellent wild rainbow trout population on the Jocassee Gorges property. SC DNR routinely stocks these areas with catchable trout along its length. In addition, these areas appear to be maintaining some larger holdover brown trout (SC DNR 2010a). Other headwater tributaries flowing into Lakes Jocassee and Keowee that support a thriving trout fishery are the Thompson River, Devils Fork, Howard Creek, Limberpole Creek, Corbin Creek, Wright Creek, Coley Creek, Cane Creek, and Laurel Fork (SC DNR 2010a).

Habitat in Lake Jocassee is similar to undeveloped North Carolina mountain reservoirs and is characterized by steep slopes with woody debris in the form of large stumps in some areas (Barwick et al. 2004). Rocky outcrops are the predominant habitat type and compose about 78 percent of the littoral zone. Other habitat types noted in the littoral zone are sand (8 percent), emergent vegetation/stream confluences (7 percent), residentially developed piers and riprap (4 percent), clay (3 percent), and cobble (1 percent).

Similar to many reservoir fisheries in the southeast, centrarchids (sunfish and bass) make up the majority of the littoral zone species abundance in Lake Jocassee. Woody debris and other instream structures (e.g., boulder riprap) are critical components for successful spawning and rearing and are likely the primary cover components in Lake Jocassee due to the lack of submerged vegetation. Sunfish species prefer shallow, low-velocity areas of the littoral zone where they construct nests/beds (small depressions) in mud, sand, and/or gravel substrates for spawning. Spawning is initiated in late winter/early spring (March-May) in South Carolina and typically extends for 4 to 6 weeks (USACE 2008a; Rohde et al. 2009). April is considered peak spawning in the Savannah impoundments for black bass. May to mid-June is considered peak spawning in the Savannah impoundments for sunfish.

Lake Jocassee is one of only a few reservoirs in South Carolina possessing the necessary combination of water temperatures and D.O. to allow the persistence of both a warmwater and a coldwater (trout) fishery year-round. Along with the effects on littoral zone fish spawning habitat in April, analysis of pelagic trout habitat in the critical summer month of September was of primary interest in Lake Jocassee. Although trout are stocked annually by the SC DNR, the sustainability of the trout fishery in Lake Jocassee is partially dependent on the availability of suitable pelagic habitat; specifically, a hypolimnion possessing water temperatures <20°C and D.O. >5 mg/L during the critical summer and fall months.

2.9.1.2 *Lake Keowee*

Fishery resources in Lake Keowee have been monitored since approximately 1973 using sampling techniques similar to those used in Lake Jocassee. Cove sampling with fish toxicants was the most frequently used technique in Lake Keowee during the early years of impoundment (Barwick et al. 1995). In the 1990s, due to the amount of residential development around the reservoir, sampling with fish toxicants was not used for future sampling of fish populations in this reservoir. Thus, the SC DNR and Duke Energy used boat-mounted electrofishing to monitor littoral fish populations. Boat-mounted electrofishing began in Lake Keowee in 1993 and continues to the present day (Barwick et al. 1995).

Littoral fish populations in the Lake Keowee electrofishing surveys consisted primarily of warmwater fish species with occasional cool water and coldwater species noted. Estimated abundances ranged from 319 to 1,981 fish/3,000 m of shoreline, weighing from 28.3 to 63.4 kg, in the lower portion of the reservoir, from 520 to 2,117 fish/3,000 m of shoreline, weighing from 18.9 to 71.4 kg, in the middle area of the reservoir, and from 232 to 2,064 fish/3,000 m of shoreline, weighing 29 to 51.5 kg, in the upper area of the reservoir. Total numbers of fish collected appeared to be similar in all areas, but total biomass was somewhat higher in the lower portion of the reservoir, in comparison to the total biomass noted in the middle and upper area of the reservoir (Barwick et al. 1995). Twenty-eight fish species representing eight families and two hybrid complexes (sunfish and black bass) were collected during surveys.

It appears the composition of the major fish species in Lake Keowee has remained generally similar over many years. Except for an occasional rainbow or brown trout, which are stocked in Lake Jocassee by the SC DNR and apparently enter Lake Keowee via operation of the Jocassee Pumped Storage Station or are stocked by the SC DNR in tributary streams, all other littoral species of fish are either indigenous or naturalized to the reservoir and are reproducing naturally (Barwick et al. 1995).

Lake Keowee's fishery is similar to Lake Jocassee except water quality characteristics do not support a sustainable year-round coldwater trout fishery. Sunfish and black bass represent the most critical management component, with littoral zone habitat loss and spawning success as the primary potential impact. Littoral fish habitat in Lake Keowee is similar to most residentially-developed Piedmont reservoirs in North Carolina and South Carolina. Since the reservoir bottom was completely cleared prior to impoundment, piers and riprap from residential development provide most (approximately 33 percent) of the subsurface and near surface habitats in the reservoir. The second most abundant habitat type is clay substrate, composing about 25 percent of the littoral zone. Other habitats include cobble (13 percent), emergent vegetation/stream confluences (12 percent), and sand (9 percent). Habitats in Lake Keowee are associated with relatively shallow or moderately sloping banks having little to no naturally-occurring woody debris.

2.9.1.3 *Hartwell Lake*

Hartwell Lake and its tailrace provide habitat for both warmwater and coldwater fisheries. The reservoir area supports a large warmwater fishery including such species as white and striped bass, hybrid bass, largemouth bass, bluegill, pumpkinseed, redear sunfish, yellow perch, walleye, and catfish. Non-game species found within the reservoir include blueback herring, common carp, longnose gar, redhorse and spotted sucker. The GA DNR and SC DNR both actively stock, on average, 500,000 to 1,000,000 total striped bass and hybrid bass in Hartwell Lake. The USACE fisheries management program supports a quality sportfish population in Hartwell Lake.

USACE's management activities are coordinated with state fishery agencies of both Georgia and South Carolina.

The Hartwell tailrace supports a coldwater trout fishery that is supported by stocking from both states. The waters are described as having no evidence of natural trout reproduction, but they are capable of supporting trout throughout the year. Striped bass and walleye are also found in this coldwater fishery (USACE 2008a). Study findings also indicate striped bass and blueback herring habitat becomes quite restricted during reservoir stratification due to the D.O. and temperature requirements of these cool water fish. The results of these stratification conditions are the congregation of herring in the penstock area and fish kills from entrainment; however, operational procedures are used to minimize this entrainment (USACE 2008a).

During each spawning season, the USACE closely monitors reservoir temperatures and levels. Bass and crappie spawn in the spring when water temperatures approach 70°F, which at Hartwell Lake generally occurs around the third week in April. Because the fish spawn in shallow water (i.e., 1 to 8 feet deep), special care is taken to ensure reservoir elevations do not fluctuate too much, leaving the eggs stranded. Therefore, from the time surface water temperatures reach 65°F until three weeks after the temperatures reach 70°F, which is the spawning period, the USACE limits reservoir elevation fluctuations to less than 6 inches to the extent practicable[6].

2.9.1.4 *RBR Lake*

The fishery resources of RBR Lake have been extensively studied. The USACE and the University of Georgia Cooperative Fish and Wildlife Research Unit (GA COOP) began baseline studies of fishery resources in RBR Lake in 1990. These studies included cove fish toxicant sampling, gill net sampling, electrofishing, and telemetry studies. SC DNR has conducted fisherman creel surveys on RBR since 1991. GA DNR has conducted fisherman creel surveys in the RBR tailrace since 1988 (USACE 2008a).

[6] Maintaining stable reservoir elevations during droughts may not be possible.

RBR Lake supports a variety of fish species including largemouth bass, spotted bass, redeye bass, threadfin shad, gizzard shad, blueback herring, bluegill, redear sunfish, channel catfish, brown bullhead, black crappie, yellow perch, white perch, spotted sucker, and common carp. Small numbers of hybrid bass and striped bass are caught each year in RBR Lake (USACE 2008a). Approximately 29,000 striped bass fingerlings were stocked in RBR in May 2004 in an attempt to establish a trophy striped bass fishery (GA DNR 2008). The GA DNR suggests larger striped bass caught in RBR Lake likely originated in Hartwell Lake. The reservoir water surface elevation fluctuates daily because of generation and pumping operations.

2.9.1.5 *JST Lake*

As with the other upstream impoundments, JST Lake is primarily a warmwater fishery. Largemouth bass, sunfish, and crappie make up the majority of important recreational species, as well as the stocked cool water striped bass. On average, 750,000 to 1,000,000 total striped and hybrid striped bass are stocked in JST Lake each year (USACE 2008a). Blueback herring are considered an important forage fish for striped bass and other predators.

The fishery resources of JST Lake have been extensively studied by the USACE, and the GA COOP began baseline studies of fishery resources in JST Lake in 1986. These studies included cove rotenone sampling, gillnet sampling, electrofishing, and telemetry. The Clemson University Cooperative Fish and Wildlife Research Unit (CU COOP) conducted a commercial creel estimate and a population estimate of blueback herring. SC DNR has conducted fisherman creel surveys on JST Lake since 1991 (USACE 2008a).

Common fish species in JST Lake include largemouth bass, bluegill, redear sunfish, hybrid bass, striped bass, black crappie, brown bullhead, channel catfish, flathead catfish, white perch, yellow perch, threadfin shad, gizzard shad, and blueback herring. SC DNR and GA DNR both actively stock hybrid bass and striped bass in JST Lake

The RBR tailrace supports a substantial fishery for striped and hybrid bass, and white perch. The tailrace makes up only 2 percent of the surface area of JST Lake, but accounts for approximately 10 percent of the total harvest of these species. Fish abundance in the RBR tailrace generally peaks in the summer and is lower in the winter. A commercial fishery for blueback herring exists in the RBR tailwaters. Blueback herring are used by fishermen as bait in both Georgia and South Carolina (USACE 2008a).

2.9.1.6 *Lower Savannah River Basin (Riverine Sections)*

Riverine fish habitats in the Savannah River Basin have been highly modified or converted to lacustrine habitat by construction of major dams and reservoirs inundating the upper half of the Savannah River Basin. This large-scale habitat conversion has changed the relative abundance and diversity of fish species from a system dominated by migratory diadromous fish to more localized riverine and lacustrine-dominated fish communities (USACE 2008a).

In the riverine portions of the Savannah River Basin downstream of JST Lake, a comprehensive fishery survey concluded the lower Savannah River riverine sections support an abundant and diverse fish community (Schmitt and Hornsby 1985). Based on numbers and weight collected, the most abundant gamefish found during the study were largemouth bass, chain pickerel, black crappie, yellow perch, redbreast sunfish, bluegill, redear sunfish, warmouth, and pumpkinseed.

Important non-game fish found during the study included longnose gar, bowfin, white catfish, channel catfish, common carp, spotted sucker, robust redhorse, striped mullet, and brown bullhead. The most important forage fish found during the study were gizzard shad and a number of minnow species. The diadromous fishes found to be inhabiting the lower Savannah River include striped bass, American shad, hickory shad, blueback herring, shortnose sturgeon, Atlantic sturgeon, and the catadromous American eel (USACE 2008a).

Although greatly reduced from former abundance, diadromous fish are an important component of the Savannah River's sport and commercial fisheries (USACE 2008a). American shad, blueback herring, and lesser numbers of striped bass and sturgeon migrate to the NSBL&D facility, which is the first major obstruction to fish passage on the river. A portion of the migratory fish population continues to migrate upstream to historical spawning grounds upstream of the facility (USACE 2008a). Some species pass upstream by swimming through fully opened dam gates at river flows of 16,000 cfs or higher, and by swimming through the navigation lock when it is operated in a manner suitable for fish passage (USACE 2008a). Additional fish movement is expected at the lock and dam when USACE constructs the fish bypass at that location as part of the Savannah Harbor Expansion Project. Shortnose sturgeon and other important species have been identified at gravel bars downstream of the NSBL&D (RM 179–190, 275–278, and 286) during spawning months of February and March (USACE 2008a). Research conducted in 1999–2000 indicated there was no observed increase in recruitment of shortnose sturgeon into the population over the previous eight years (USACE 2008a). However, an increased number of sturgeon have been observed in the river due to a SC DNR stocking enhancement program, which ended in 1992.

Presently, the lower Savannah River provides important striped bass habitat (USACE 2008a). Although the majority of the historical upstream spawning habitat for striped bass has been inundated by the reservoirs, some remaining rocky rapid habitats exist in the Augusta Shoals from just below the NSBL&D upstream to Stevens Creek Dam (USACE 2008a). After construction of the mainstem dams and prior to initiation of the 1977 Tidegate operation, the primary spawning area for striped bass in the Savannah River system was the tidal freshwater zone approximately 18 to 25 miles from the river mouth (i.e., Little Back River) (USACE 2008a). Salinity changes due to the Tidegate operation (1977–1991) reduced the extent of this tidal freshwater zone (USACE 2008a).

2.9.2 *Aquatic Plants*

There are limited aquatic plant populations in the Duke Energy and USACE reservoirs and in the Savannah River Basin in general. These aquatic plants or submerged aquatic vegetation (SAV) occur primarily in littoral zone habitats of reservoirs where ample sunlight penetrates the water column. Most of these species are non-native and/or invasive species introduced by humans. While certain aquatic plants or SAV are beneficial to fisheries, they can cause a loss of biodiversity, habitat degradation, loss of recreation, and other ecological consequences when they are not controlled or prevented. In addition, these species also threaten native species and their habitats by out-competing them for resources like sunlight, water, and nutrients (National Park Service and University of Georgia 2011).

The Duke Energy and USACE management goals for these species are to eliminate, reduce growth, and/or prevent the spread of invasive plants to other waterbodies. Several techniques are used to achieve these management goals, including winter drawdown, chemical treatment, and manual removal.

In support of the Keowee-Toxaway Project relicensing, a botanical resources inventory of the Keowee-Toxaway Project area was performed in 2012 and included an evaluation of aquatic plants in Lake Jocassee and Lake Keowee.

2.9.2.1 *Lake Jocassee*

Lake Jocassee has no native or exotic aquatic plant species populations, possibly due to bottom substrates and water level fluctuations within the reservoir preventing the establishment of most aquatic plants (Duke Energy 2011).

2.9.2.2 *Lake Keowee*

During the 2012 botanical resources study, aquatic coontail and parrot feather were found in Lake Keowee. Neither of these species is included on the state “noxious” aquatic weed list, but they are both invasive in the Piedmont of South Carolina. Additional information can be found in the 2012 Botanical Resources Final Study Report filed with FERC on January 18, 2013.

Hydrilla, an exotic invasive plant, was discovered in 1995, growing in scattered cove heads in the Cane Creek arm of Lake Keowee. Duke Energy and the SC DNR treated the approximately three hectares (7.4 acres) of hydrilla with approved chemicals and manually removed small shallow beds when they were observed. Hydrilla was last observed in Lake Keowee in 2002. Annual surveys for hydrilla continue in Lake Keowee, but no additional infestations have been observed (Duke Energy 2011). Hydrilla was not observed in Lake Keowee during the 2012 botanical resources study.

2.9.2.3 *Hartwell Lake*

Recent surveys on Hartwell Lake have shown aquatic plants have not become abundant in Hartwell Lake. No native species of aquatic plants were noted; however, two exotic and invasive species, hydrilla and water primrose, have been found. The water primrose was found in Eighteen-Mile Creek but it did not appear to have increased relative to previous studies (USACE 2008a). A small population of hydrilla was located between the Highway 93 Bridge and Highway 123 Bridge in Pickens County, South Carolina, but due to falling water levels, the hydrilla was exposed and appeared to have died due to desiccation. However, the USACE is concerned additional hydrilla will be moved from other waterbodies into Hartwell Lake (USACE 2008a). The overall aquatic plant growth in Hartwell Lake has not reached nuisance levels requiring treatment as stated in Executive Order 13112, which concludes federal agencies must prevent the introduction of invasive species and control populations of the species in a cost-effective and environmentally sound manner (USACE 2008a).

2.9.2.4 *RBR Lake*

Studies conducted on RBR Lake have been undertaken periodically to determine aquatic plant distribution and abundance. Hydrilla was discovered in RBR Lake during 2002, but apparently the populations died out and it has not been seen since that time (USACE 2008a). Approximately 8 hectares (20 acres) of Brazilian waterweed, a known invasive aquatic plant, was found in the Dry Fork Creek area and 2 miles downstream of Hartwell Dam. At present, the growth of the Brazilian waterweed in RBR Lake has not reached nuisance levels requiring treatment (USACE 2008a).

2.9.2.5 *JST Lake*

The USACE monitors and treats the hydrilla in JST Lake regularly (USACE 2008a). Hydrilla in JST Lake covers approximately 2,629 hectares (approximately 6,500 acres) and is found along approximately 863 km (536 miles) of JST Lake shoreline in Georgia and South Carolina (USACE 2008a). The USACE estimated in 2008 hydrilla populations occupied approximately 9.2 percent of the total reservoir surface at normal summer elevation (USACE 2008a). Infestations of hydrilla have been found in the following areas in JST Lake (Table 2.9-1).

Table 2.9-1 Location of Hydrilla Infestations in JST Lake

Location	County	State
Savannah River from Little River Subdivision to Savannah Lakes Marina	McCormick	SC
Benningsfield and Dordon Creeks	McCormick	SC
Hickory Knob State Park and Hickory Knob Subdivision	McCormick	SC
Soap Creek from Soap Creek Subdivision to Hwy 378 Bridge	Lincoln	GA
Wells Creek	Lincoln	GA
Mistletoe State Park / Cliett Creek	Columbia	GA

Source: USACE 2008a

2.9.2.6 *Lower Savannah River Basin*

Native and exotic aquatic plant populations in the lower Savannah River Basin are monitored periodically throughout the growing seasons. In addition to the species mentioned in Sections 2.9.2-1 through 2.9.2-5, water hyacinth, and fanwort were also identified in the drainage. None of the species appear to pose sufficient problems to operation of the NSBL&D or uses of the area to require treatment (USACE 2008a).

2.9.3 ***Wetlands***

2.9.3.1 *Lake Jocassee*

Generally, the terrain abutting Lake Jocassee is steep, which inhibits the formation of wetlands and riparian areas along the shoreline due to the existing slope and bedrock exposure. However, a review of existing information indicates wetlands exist at the confluences of streams and within various shallow cove areas (National Wetland Inventory [NWI] 2010; Dorcas 2009). The dominant vegetation within these wetlands includes black willow, red maple, hop hornbeam, American elm, box elder, buttonbush, elderberry, sensitive fern, and spotted lady's thumb (Nelson 1986).

One major type of wetland habitat (palustrine emergent [PEM]) is located adjacent to Lake Jocassee, (Cowardin et al. 1979). PEM habitats typical of those found adjacent to Lake Jocassee are characterized by a dominance of rushes, sedges, hydrophytic grasses such as reed canarygrass, various knotweed species such as tear thumb, halberd-leaved tear thumb, and painted lady's thumb (Nelson 1986).

Wetland delineation field surveys performed during the summer of 2012 identified four discrete wetland habitats on or adjacent to the Lake Jocassee reservoir, primarily consisting of PEM wetlands with very limited palustrine scrub-shrub (PSS) components. Approximately 48.2 acres of wetlands were identified on or adjacent to Lake Jocassee during the 2012 wetland study. Additional information can be found in Duke's Final Wetlands Study Report that it filed with FERC on January 25, 2013.

2.9.3.2 *Lake Keowee*

Like Lake Jocassee, the terrain abutting Lake Keowee is fairly steep which inhibits the formation of wetlands along the shoreline except at the confluences of streams and within various shallow cove areas (NWI 2010; Dorcas 2009). The dominant vegetation within these wetlands includes black willow, red maple, hop hornbeam, American elm, box elder, buttonbush, elderberry, sensitive fern, and spotted lady's thumb (Nelson 1986).

Palustrine emergent habitats typical of those found adjacent to Lake Keowee are characterized by a dominance of rushes, sedges, hydrophytic grasses such as reed canary grass, various knotweed species such as tear thumb, halberd-leaved tear thumb, and painted lady's thumb (Nelson 1986). PSS habitats are dominated by low to medium height trees and shrubs, generally with a diverse herbaceous strata (Cowardin et al 1979). Typical species found include spicebush, maleberry, common winterberry, hazel alder, red maple, and black willow (Nelson 1986). Palustrine forested habitats are dominated by mature tree species. These areas may not always have a well-developed understory or herbaceous layer depending on canopy density (Cowardin et al. 1979). Typical species found within the area include red maple, black willow, American elm, and swamp chestnut oak (Nelson 1986).

Wetland field surveys performed during the summer of 2012 identified 45 discrete wetland habitats on or adjacent to Lake Keowee, many of which are influenced by the active or relic presence of beaver, and are a mosaic of PEM and PSS, and to a lesser degree palustrine forested (PFO), habitats with pockets of open water interspersed throughout the wetland. Approximately 137.1 acres of wetlands were identified on or adjacent to Lake Keowee during the 2012 wetland study. Additional information can be found in Duke's Final Wetlands Study Report that it filed with FERC on January 25, 2013.

2.9.3.3 *Hartwell Lake*

There are approximately 676 acres of wetlands adjacent to Hartwell Lake (NWI 2010). Approximately 483 acres are classified as palustrine emergent wetland habitat, 48 acres as PSS wetland habitat, and 145 acres as palustrine forested wetland (NWI 2010).

2.9.3.4 *RBR Lake*

There are approximately 679 acres of various types of wetlands adjacent to RBR Lake. Approximately 38 acres are classified as palustrine emergent wetland habitat, 63 acres as PSS wetland habitat, and 578 acres as palustrine forested wetland (NWI 2010).

2.9.3.5 *JST Lake*

There are approximately 1,331 acres of various types of wetlands adjacent to JST Lake. Approximately 358 acres are classified as palustrine emergent wetland habitat, 187 acres as PSS wetland habitat, and 786 acres as estimated to be palustrine forested wetland (NWI 2010).

2.9.3.6 *Lower Savannah River Basin*

The majority of the wetland habitat in the riverine section of the Savannah River downstream of JST Lake is associated with the palustrine forested wetlands dominating the extensive alluvial plain of the Savannah River (USACE 2008a). The wetland habitats in the floodplain, such as swales, sloughs, and back swamps are dominated by bald cypress, water tupelo, and swamp tupelo. Slightly higher areas, which are usually flooded for much of the growing season, are often dominated by overcup oak and water hickory. A majority of the Savannah River floodplain consists of flats or terraces and these habitats tend to be flooded during most of the winter and early spring and one or two months during the growing season. Laurel oak is the dominant species on these flats and green ash, American elm, sweetgum, and sugarberry are often present. Swamp chestnut oak, cherrybark oak, and loblolly pine are found on the highest elevations of the floodplain, which are only flooded infrequently during the growing season (USACE 2008a).

On the lower Savannah River downstream of Interstate Highway 95, well into the coastal plain, tidal palustrine emergent wetlands become prevalent. Tidal palustrine emergent wetlands are flooded twice daily by tidal action. These marshes are vegetated with a diverse mixture of plants including giant cutgrass, spikerushes, and various other plant species adapted to the tidal flooding regime (USACE 2008a). The diverse tidal freshwater marsh located at the upper end of the estuary is particularly valuable, since it has substantially declined in acreage over the years.

2.9.4 *Wildlife*

Wildlife species can be found in various habitats within and immediately adjacent to the reservoirs. Habitats include open water; wetlands (emergent, shrub/scrub and forested); and uplands (forested, open/field, and disturbed). Some of these habitats can be affected by fluctuations in reservoir levels and others are likely to remain unaffected. Upland habitats are less likely to be impacted due to their distance from the reservoirs. In addition, wetland habitats not dependent on reservoir level as a source of hydrology are less likely to be impacted.

However, open water and wetland habitats dependent on reservoir level for hydrology and primary productivity, such as fringe wetlands, could be affected by reservoir fluctuations (e.g. 10 feet or more. Therefore, wildlife species using those habitats could potentially be affected.

Reptiles and amphibians use open water habitats of reservoirs. Species such as Eastern painted turtle, common musk turtle, snapping turtle, spiny softshell turtle, yellow-bellied slider, water snakes, newt, and frogs are predominantly associated with the shallow water areas of reservoirs. These species use the open water habitats for breeding, foraging, and hibernation.

Similar to reptiles and amphibians, birds use the shoreline and shallow open water habitats within reservoirs. These open water habitats are used as migration stopovers (resting habitat) for numerous species of ducks and geese as well as wading birds such as egrets, herons, and sandpipers. During the migration stopover, these species also use these areas for feeding prior to continuing their migration. Some of these migratory species use the reservoirs as overwintering habitat including Bonaparte’s and ring-billed gulls, common loons, and hooded mergansers.

In addition to the use of these habitats for feeding and overwintering by migratory species, resident avian species use open water for feeding. Examples of birds identified in the study area using the reservoir for feeding during the winter include belted kingfishers and great blue herons feeding in the shallow waters of the open water habitat.

Mammals commonly use open water habitats. Bats are one of the most common mammals to feed over the reservoirs. In addition, furbearers such as mink, American beaver, muskrats, and other semi-aquatic mammals use shallow water for feeding as a means of transportation to other habitats.

Reservoir Dependent Wetland (RDW) habitats are composed of emergent, shrub/scrub, and forested wetland habitats existing due to the water level in the reservoirs. As with the open-water habitat, RDW are widely used by wildlife during various parts of their life cycle. Reptiles and amphibians use RDW habitats near the shorelines of reservoirs. For example, a variety of turtles and snakes use RDW for feeding and basking, and numerous amphibians breed, lay eggs, forage, and undergo their aquatic larval stage in these habitats. Some species, such as the Eastern newt, could spend their entire life cycle in RDW habitats.

Avian species use RDW habitats adjacent to reservoirs as a migration stopover. Examples include numerous species of ducks and geese, as well as Neotropical migrants such as flycatchers, vireos, thrushes, and warblers. During the migration stopover, these species also use vegetated areas for feeding prior to continuing their migration. Some of these migratory species use RDW habitats as their overwintering habitat including swamp sparrows, yellow-rumped warblers, and Wilson's snipe.

In addition, RDW habitats also provide food and nesting for resident avian species. Song sparrows, yellow warblers, eastern kingbirds, mallard, wood duck, and Canada geese are a few examples of species that nest and raise their young in RDW habitats.

Some of the same mammals using open water habitats also use RDW habitats. Bats feed over the wetland habitats as they forage for flying insects such as midges and mosquitoes. In addition, the opossum, white-tailed deer, mink, American beaver, and other semi-aquatic mammals utilize RDW habitats for foraging and raising young.

2.9.4.1 *Lakes Jocassee and Keowee*

The wildlife species associated with Lakes Jocassee and Keowee include both aquatic (excluding fishes) and terrestrial species. Mussels, amphibian and reptiles, avian, and mammal species found in and adjacent to Lakes Jocassee and Keowee are included in this section.

2.9.4.1.1 Mussels

Mussel shell and live mussel collections were conducted during a major drawdown in Lake Jocassee in 2007 (Duke Energy 2011). Three mussel species were documented as extant in Lakes Jocassee and Keowee: paper pondshell, eastern floater, and the Florida pondhorn. In Lake Jocassee, the paper pondshell appears restricted to the northern portion of the reservoir, while the Florida pondhorn was noted only in the southern portion of the reservoir. The eastern floater was found only where the Toxaway River enters Lake Jocassee. Based on the total number of shells found, the paper pondshell (150 shells) was the most abundant mussel in Lake Jocassee followed by the six Florida pondhorns, and one eastern floater (Alderman 2009). In Lake Keowee, the paper pondshell and eastern floater were well distributed throughout the reservoir, with the eastern floater (80 shells) being somewhat more abundant than the paper pondshell (62 shells) based on the total number of shells and live specimens found. However, the Florida pondhorn appeared to be restricted to the middle portions of the reservoir and it was the least abundant (20 shells) of the mussels found in Lake Keowee (Alderman 2009). No Rare, Threatened, or Endangered (RTE) mussel species were collected during this study.

2.9.4.1.2 Amphibians

Thirty-seven species and subspecies of amphibians have been reported to occur in the watershed, of which 14 belong to the order Anura (frogs and toads) and 23 belong to the order Caudata (salamanders). The most common amphibian species in the vicinity of Lake Jocassee were salamanders, including the seal salamander, Ocoee salamander, three-lined salamander, and Southern gray-cheeked salamander. The Northern dusky salamander, Southern two-lined salamander, and spring salamander were also common (Dorcas 2009).

Salamanders were relatively less common around Lake Keowee, where the most abundant amphibians tended to be frogs, including the Northern cricket frog, spring peeper, bullfrog, and green frog. The American toad and the Eastern newt were abundant as well, while Cope's gray tree frog and the pickerel frog were common (Dorcas 2009).

2.9.4.1.3 Reptiles

The reptile fauna in the watershed included seven species of turtles (order Testudines). The Eastern painted turtle and common musk turtle were abundant in the area of Lake Keowee; the Eastern river cooter and Eastern box turtle were common as well. Other turtles observed near the reservoirs included the snapping turtle, spiny softshell turtle, and yellow-bellied slider (Dorcas 2009).

Fifteen species of snakes were documented from the Jocassee/Keowee watershed, based on the reference material available. Some of the species found were Northern water snake, black rat snake, Eastern garter snake, worm snake, black racer, ring-neck snake, Eastern kingsnake, Eastern milk snake, Northern rough green snake, pine snake, queen snake, brown snake, and red-bellied snake. Two species of the family Viperidae are found in the watersheds including the copperhead and timber rattlesnake (Dorcas 2009, Garton 2004; Kohlsaat et al. 2005; Duke Energy 2011).

Eight species of lizards were reported from the watersheds. The green anole was common in the vicinity of Lakes Jocassee and Keowee. Some of the species found were the Northern fence lizard, Eastern six-lined racerunner, five-lined skink; Southeastern five-lined skink; broad-headed skink; ground skink; and Southern coal skink (Dorcas 2009, Pitts 1997; Duke Energy 2011).

2.9.4.1.4 Birds

The Lake Jocassee and Lake Keowee watershed supports populations of at least 98 species of birds. Common species seen around the reservoirs include wild turkey, American woodcock, mourning dove, bobwhite quail, ruffed grouse, red-tailed, red-shouldered, and broad-winged hawks; Cooper's hawk; sharp-shinned hawk; Eastern screech-owl; and barred owl (Duke Energy 2011).

Additional common avian species known to occur in the Jocassee/Keowee watersheds are American crow, blue jay, blue-gray gnatcatcher, Carolina wren, downy woodpecker, Northern cardinal, red-eyed vireo, Summer Tanager, Tufted Titmouse, yellow-throated vireo, yellow-billed cuckoo, barn swallow, black-and-white warbler, brown-headed cowbird, common yellow-throat, Eastern bluebird, Eastern towhee, field sparrow, Northern mockingbird, white-eyed vireo, American goldfinch, and the yellow-breasted chat (Breeding Bird Atlas 1995). Some notable winter visitors to these reservoirs include common loons, pied-billed and horned grebes, and the bald eagle (Duke Energy 2011).

An avian study was performed in 2012 and consisted of surveys for avian resources through use of point counts at 52 established point count stations around Lake Keowee and Lake Jocassee in both South Carolina and North Carolina. During the 2012 avian study, 150 separate avian species were observed. The 2012 avian study also identified two great blue heron rookeries located at the Dodgins Creek and Eastatoe Creek areas on Lake Keowee. Additional information regarding the 2012 avian study can be found in the Final Avian Study Report filed with the FERC on February 22, 2013.

2.9.4.1.5 Mammals

Forty-eight species and subspecies of mammals have been reported to occur in the Jocassee/Keowee watershed. The area maintains one of the largest American black bear populations in the Southeast, and the mountainous regions of the watershed constitute a major portion of the quality black bear habitat in South Carolina. White-tailed deer and wild boar are abundant as well (Rankin et al. 1998; Duke Energy 2011). Larger predators found in the watershed include coyotes, bobcats, and gray and red foxes. Populations of smaller carnivores such as striped and Eastern spotted skunks, mink, and northern raccoons are also present (Rankin et al. 1998). At least nine species of bats have been reported including the big brown bat, red bat, and tricolored bat, as well as rare species such as Rafinesque's big-eared bat and the Eastern small-footed myotis (Duke Energy 2011). The watershed is also home to American beavers; muskrats; Virginia opossum; three species of cottontails; and several species of shrews, mice, and voles (Duke Energy 2011).

A comprehensive survey of the mammalian fauna of the Lake Keowee and Lake Jocassee area was conducted during three seasons (spring, summer, and autumn) in 2012. The 2012 survey documented 40 species of mammals within the study area, six of which are listed as rare, threatened, or endangered. Additional information regarding the 2012 mammalian survey can be found in Duke's Final Mammalian Study Report that it filed with the FERC in February 2013.

2.9.4.2 *Hartwell, RBR, and JST Reservoirs*

2.9.4.2.1 Mussels

No public information exists on mussel species in the USACE reservoirs. It is assumed that species similar to those found in Lakes Jocassee and Keowee also occur in the USACE impoundments.

2.9.4.2.2 Reptiles and Amphibians

The study area provides excellent habitat for a large number of reptiles and amphibians. Wetland habitats support many species of frogs including the bullfrog, green frog, southern leopard frog, several species of tree frogs, cricket frogs, and chorus frogs. Turtles found in the wetlands include the river cooter, Florida cooter, eastern chicken turtle, snapping turtle, and common musk turtle. Snakes found in the wetlands include the water snakes and eastern mud snake, (USACE 2008a).

2.9.4.2.3 Birds

Several of the most common bird species noted using Hartwell Lake or in the immediate vicinity of the reservoir include red-shouldered hawk, red-tailed hawk, ruby-throated hummingbird, Eastern kingbird, blue jay, American crow, Carolina chickadee, tufted titmouse, white-breasted nuthatch, American robin, Northern mockingbird, brown thrasher, Northern cardinal, red-winged blackbird, ring-necked duck, lesser scaup, and brown-headed cowbird (USACE 2008a and USACE 1981).

Additionally, some avian species commonly seen or heard in the surrounding uplands of Hartwell, RBR, and JST Lakes include: wild turkey, American bittern, great blue heron, osprey, red-tailed hawk, mourning dove, whip-poor-will, belted kingfisher, red-headed woodpecker, Eastern kingbird, blue jay, American crow, tufted titmouse, Eastern bluebird, American robin, gray catbird, Northern mockingbird, brown thrasher, Northern parula, Northern cardinal, red-winged blackbird, brown-headed cowbird, ring-necked duck, and lesser scaup (USACE 2008a and USACE 1981).

2.9.4.2.4 Mammals

Around Hartwell, RBR, and JST Lakes, furbearers and other mammals are an important component of these wetlands and include American beaver, muskrat, mink, northern river otter, and gray fox. White-tailed deer, and even black bear in the more isolated areas, use the bottomlands. Palustrine emergent wetlands also provide excellent habitat for furbearing mammals. Terrestrial species from surrounding areas often use the fresh marsh edge for shelter, food, and water. These include Northern raccoon, Virginia opossum, cottontails, nine-banded armadillo and coyote and bobcat (USACE 2008a and USACE 1981).

2.9.4.3 *Lower Savannah River Basin*

2.9.4.3.1 Mussels

In the portion of the Savannah River downstream of the USACE reservoirs, the wildlife associated with forested wetlands is numerous and diverse. In 2006, the USFWS studied freshwater mussels in the Savannah River to determine species composition and distribution of mussels (Savidge 2007). Twenty-six freshwater mussel species were identified during the survey efforts. With the exception of sites within the Augusta Shoals area, mussels were unevenly distributed in the surveyed areas, which is reflective of the distribution and quality of microhabitats within a particular river segment. In general, mussels were most abundant in the deepest part of the channel at the base of the river bank, and rare to absent in the shifting sand dominated runs in the center of the channel (USACE 2008a).

Atlantic pigtoe and Savannah lilliput were both observed in the 2006 mussel survey. Both of these species are experiencing range-wide declines. Atlantic pigtoe was found only in the Augusta Shoals area. This species has not been observed in any other Georgia or South Carolina rivers in many years. The population of Savannah lilliput upstream of Little Hell boat landing (Allendale County) may be the largest remaining population of this species (USACE 2008a Savidge 2007).

The flowing portion of the Savannah River is also reported to provide habitat for the Altamaha arc-mussel and Brother spike. The 2006 discovery of four species not previously known to occur in South Carolina demonstrates the incomplete knowledge regarding the mussel fauna of the Savannah River (Savidge 2007). The objective of the 2006 mussel survey was an attempt to estimate species composition and distribution in the Savannah River, but the surveyors primarily searched deepwater habitat in the river (USACE 2008a and Savidge 2007).

2.9.4.3.2 Reptiles and Amphibians

The study area provides excellent habitat for a large number of reptiles and amphibians. Wetland habitats support many kinds of frogs including the bullfrog, green frog, southern leopard frog, several species of tree frogs, cricket frogs, and chorus frogs. Turtles found in the wetlands include the river cooter, Florida cooter, eastern chicken turtle, snapping turtle, and common musk turtle. Snakes found in the wetlands include the water snakes, eastern mud snake, and eastern cottonmouth (USACE 2008a).

2.9.4.3.3 Birds

Palustrine emergent wetlands also provide habitat for many bird species. Resident, transient, and migrating birds of both terrestrial and aquatic origin use food and shelter found in this community. Some species use freshwater marshes for nesting and breeding. Waterfowl feed upon fresh marsh vegetation, mollusks, insects, small crustaceans, and fish found in the fresh marsh community. Wading birds such as the wood stork, great blue heron, little blue heron, green heron, and great egret also heavily use the tidal freshwater marsh. The lower Savannah River area is part of the Atlantic Flyway for migrating birds, and forested wetlands provide important wintering habitat for many waterfowl species and nesting habitat for wood ducks. Many species of Neotropical migratory birds, woodpeckers, hawks, and owls use the bottomlands and swamps (USACE 2008a). The extensive floodplain bottomland forest along the lower Savannah River also provides valuable habitat for species such as the swallow-tailed kite (USACE 2008a).

2.9.4.3.4 Mammals

As with the USACE reservoirs noted above in this document, furbearers and other mammals are an important component of these wetlands and include American beaver, muskrat, mink, northern river otter, gray fox, Northern raccoon, and Virginia opossum. White-tailed deer, and even black bear in the more isolated areas, use the bottomlands. Palustrine emergent wetlands also provide excellent habitat for furbearing mammals. Terrestrial species from surrounding areas often use the tidal and freshwater marsh edges for shelter, food, and water. These include cottontails, nine-banded armadillo, coyote, and bobcat (USACE 2008a).

2.9.5 ***Protected Species***

Literature searches for potentially occurring endangered, threatened, and species of concern were completed using the databases of the USFWS, North Carolina Natural Heritage Program (NC NHP), SC DNR, GA DNR, and USACE. Based on this information, a list of potentially occurring state and federal endangered, threatened, and species of concern likely to occur in the Savannah River Basin study area was compiled. Information from counties bordering the Savannah River and associated reservoirs was used, but only listed species associated with habitats in or immediately adjacent to the reservoirs or within the Savannah River were included.

Upon compilation of the species list, federally listed threatened, endangered, proposed endangered, proposed threatened, and targeted federal species of concern were reviewed for distribution, habitat, and ecology to ascertain if there were species that could be found within the area of potential impacts within the study area. A summary of this information is provided in Appendix F. In addition, the bald eagle was reviewed due to its protection under the Bald and Golden Eagle Protection Act (BGEPA). Of those species reviewed, 11 species (Table 2.9-2) had the potential for impacts due to their distribution, habitat, or ecology within the study area.

Table 2.9-2 Federally Proposed and Protected Species Located in the Savannah River Basin Impact Study Area

Common Name	Federal Status	State Status
bald eagle	BGEPA	E (SC, GA)
manatee	E	E (GA)
wood stork	E	E (SC)
bluebarred pygmy sunfish	FSC*	N/A
shortnose sturgeon	E	E (SC, GA)
Atlantic sturgeon	PE	E (SC, GA)
robust redhorse	FSC*	N/A
American eel	PT	N/A
yellow lampmussel	FSC*	N/A
Savannah lilliput	FSC*	N/A
Atlantic pigtoe	FSC*	E (GA)
shoals spider-lily	FSC*	N/A
Altamaha arcmussel	FSC	N/A
Brother spike	FSC	N/A
Blueback herring	FSC	N/A

Source: NC NHP 2010, SC DNR 2006b, GA DNR 2007.

Notes: E = Endangered, T = Threatened, S/A= Similarity of Appearance, BGEPA = Bald & Golden Eagle Protection Act, PT = Proposed Threatened, PE = Proposed Endangered, FSC = Federal Species of Concern, N/A = Not Applicable,* = Target Species

2.9.6 *Special Biological Issues*

Approximately 150,000 acres of land surrounding Lake Jocassee is protected through public ownership. The lands are owned by the SC DNR, the U.S. Forest Service, the State of North Carolina, and the South Carolina Forestry Commission. Duke Energy owns land in the area for potential additional power generation and electric transmission facilities but has given up rights for other types of development through easements to the State of North Carolina and the SC DNR.

The Jocassee Gorges area was designated a State Important Bird Area based on the presence of a large portion of South Carolina's breeding populations of Swainson's warbler and worm-eating warbler, and on the availability of cove forest habitat and young Eastern hemlock stands, with which these birds are associated. Swainson's warbler was on the 2007 Watchlist of the National Audubon Society based on regional declines in numbers, potentially attributable to habitat loss (National Audubon Society 2010).

The tidal freshwater marsh of the SNWR in the lower Savannah River Basin supports a diverse plant community providing habitat for a wide variety of wildlife species. Tidal freshwater marshes are relatively scarce in the area due to past development and sea level rise, which have increased salinity levels in much of the estuary, reducing the amount of tidal freshwater marshes. According to the USFWS, the Savannah NWR contains only approximately 2,800 acres of the 6,000 acres of tidal freshwater marshes that once occurred in the estuary (USACE 2008a).

Prior to 1977, the Savannah River supported an important naturally-reproducing striped bass population, but production of striped bass in the Savannah River estuary declined by about 95 percent. There is currently an ongoing stocking program to improve this condition. Annual stocking efforts by the GA DNR have been very successful in increasing the number of striped bass in the lower Savannah River, and current population levels approach historic levels. After a 17-year closure, the striped bass fishery was re-opened in October 2005 (USACE 2008a).

The Savannah River estuary is considered essential fish habitat (EFH) by National Oceanic and Atmospheric Administration (NOAA). This stretch originates at the mouth of the Savannah River and extends upstream over 20 miles. This EFH encompasses approximately 8.2 square miles of the river and its associated estuaries. The groups covered by this EFH are the shrimp and the snapper/grouper complex (NOAA 2010).

Certain species of shrimp move into the estuaries as a result of nearshore tidal currents as the species spawn close to shore. Additionally, some shrimp species move into the estuary during late spring and early summer seasons. After shrimp enter the Savannah River estuaries, post-larval shrimp occupy nursery areas offering abundant food, suitable substrate, and shelter from predators. Smaller individuals of these shrimp species may remain in the estuary during winter months (NOAA 2010).

The species of the snapper/grouper complex typically use both the pelagic and benthic habitats during their lifecycles. The juveniles of some of the species could occur in the in-shore habitats of the Savannah River. Additionally, various combinations of habitats (including in-shore) may be used during daily feeding migrations and seasonal habitat shifts (NOAA 2010).

2.10 Socioeconomic Issues

2.10.1 *Reservoir Elevation Economic Impact Analysis*

The Strom Thurmond Institute of Public and Government Affairs (STI) at Clemson University conducted three analyses of the economic effects of reservoir levels on the surrounding communities. The analyses consisted of separate studies of the three reservoirs with the most potential for impacts associated with potentially large reservoir fluctuations: Lake Keowee, Hartwell Lake, and JST Lake.

The Institute conducted on analysis of the counties surrounding Hartwell Lake and reported their results in a document titled “The Hartwell Lake Economic Impact Analysis”. The study objective was to determine the incremental economic changes within the six counties from incremental changes in Hartwell Lake elevations. The counties all share a border with Hartwell Lake and include Pickens, Anderson, and Oconee Counties in South Carolina and Franklin, Hart, and Stephens Counties in Georgia. Information and data gathered and used in The Hartwell Lake Economic Impact Analysis included: county-level sales tax revenue according to industry classifications; 2007 estimates of total property value of lakefront real estate (segmented by county); residential and commercial development in relation to reservoir elevations (value and number of exchanges segmented by county); an estimation of economic impacts due to ancillary fees or loss of income related to real estate exchanges; and an assessment of the major roadways and potential development spots for increasing tourism and residential and commercial growth. In addition, information from Standard Industrial Classification (SIC) codes (including businesses and commercial concessionaires such as marinas, etc.) was incorporated into the Hartwell Lake economic assessment. The goal of the analysis was to identify a relationship between incremental reservoir levels and economic changes. The Institute used results from the USACE's HEC-ResSim model simulations for Hartwell Lake in their analysis.

Duke Energy retained STI to perform similar economic impact analyses based on reservoir levels at Lake Keowee and JST Lake. Similar to analysis for Hartwell Lake, these studies also developed a relationship between incremental reservoir levels and economic changes. The HEC-ResSim modeling results were also used in these two studies. A summary of findings is available in Section 4.5.1 and the full reports for the Hartwell, Keowee, and JST reservoirs are provided in Appendices P, R, and S, respectively.

2.10.2 *Environmental Justice*

Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations) was issued requiring every federal agency to consider environmental justice in its decisions by identifying and addressing the effects of all programs, policies, and activities on "minority and low income populations." Environmental justice consists of three fundamental principles:

- To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations;
- To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process; and
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations (U.S. Department of Housing and Urban Development [HUD] 2010).

2.10.3 *Protection of Children*

Executive Order 13045, (Protection of Children from Environmental Health Risks and Safety Risks) requires each federal agency, to the extent possible, to:

- Make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children; and
- Ensure its policies, programs, activities, and standards address disproportionate risks to children resulting from environmental health or safety risks (White House Press Release 1997).

2.11 Coastal Zone Consistency

The 1972 Coastal Zone Management Act (CZMA) encourages coastal states to develop and implement coastal zone management programs. Pursuant to 16 U.S.C. 1456, "each Federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone shall be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved state management programs." Consultation with the relevant state agencies is required to determine if a consistency certification or determination is necessary prior to proceeding with any project falling under the jurisdiction of this Act.

There are four types of federal actions which fall under CZMA:

1. Federal agency actions including activities and developmental projects performed by a federal agency or a contractor on behalf of the federal agency;
2. Any non-federal entity actions requiring a federal license, permit, or other form of federal authorization (i.e., USACE 404 permits, NRC or FERC licenses);
3. Any project requiring approval from the Bureau of Ocean Energy Management, Regulation and Enforcement (formally Minerals Management Service) for an outer continental shelf plan; and
4. Any project by a state and local government receiving federal Assistance.

A consistency determination is a report, often part of an EA or an EIS, addressing the effects of a direct federal activity on enforceable policies of the state. A consistency certification is a statement certifying the federally permitted or funded project has been designated to meet all State and local laws and all necessary permits have been obtained.

Both the 1968 and a new Operating Agreement describe water management activities that would occur outside of the coastal zone of South Carolina and Georgia. However, changes in water flow patterns could extend downstream into the coastal zone, so an assessment of potential impacts to coastal resources is warranted.

2.12 Electric Generation

The Savannah River currently supports 26 power production facilities with a total combined generating capacity of 10,661 MW, which are described in detail in Sections 2.1.

The effects of the five alternatives on electric generation at Bad Creek Project, Jocassee Pumped Storage Station, Keowee Hydroelectric Station, and the USACE's Hartwell, RBR, and JST Projects were analyzed[7]. Under NAA, if Lake Keowee drops below 793 ft AMSL, Duke would have to shut down the ONS under certain situations. Under A1, A3, and A4, Duke would modify the ONS to enable it to continue operating. An evaluation of the potential impacts of the operating scenarios on electric generation is included in Section 4.7.

2.13 Electric Transmission

The Savannah River Basin and the electric generating facilities dependent upon it are part of the highly interconnected regional power transmission system. Loss of generation at ONS, the three USACE hydroelectric projects, and other generating stations in or near the Savannah River Basin could result in power grid reliability and stability issues throughout the region. As part of this

[7] The Bad Creek and RBR Projects were constructed after the 1968 Agreement went into effect. As a result, their influence on water storage, timing of flow releases, and hydroelectric generation has not been factored into the 1968 Agreement.

study, Duke Energy conducted an Electric Generation and Transmission Study focused on two primary areas of interest:

- A qualitative assessment of grid reliability and stability issues with no modifications to the transmission system
- A quantitative assessment related to costs of upgrading the transmission system to avoid grid reliability and stability problems during a three-unit forced outage at ONS

The results of that study are summarized in Section 4.8 and the Final Report is available in Appendix U.

2.14 Solid and Hazardous Waste Facilities

EPA lists six sites on their National Priorities List (NPL) of solid and hazardous waste facilities in the Savannah River Basin. Three of the sites are in South Carolina and three are in Georgia. Table 2.14-1 describes the general location of each listed facility within the study area.

Table 2.14-1 Solid and Hazardous Waste Facilities

EPA ID	Site Name	City	State
SCN000407714	Barite Hill/Nevada Goldfields	McCormack	SC
SCD003354412	Sangamo-Weston, Inc./Twelve-Mile Creek/Hartwell Lake	Pickens	SC
SC189000898	Savannah River Site	Aiken	SC
GAD001700699	Monsanto Corporation Augusta Plant	Augusta	GA
GAD033582461	Alternate Energy Resources, Inc.	Augusta	GA
GAN000407499	Peach Orchard Road PCE Ground Water Plume	Augusta	GA

None of the six listed sites directly adjoin Duke Energy or USACE reservoirs or the mainstem of the Savannah River. However, one of the sites (i.e., Sangamo-Weston, Inc.) is located along Twelve-Mile Creek, which is a tributary to Hartwell Lake. According to the EPA, construction of all physical structures necessary to achieve clean up goals has been completed with remedial actions continuing until all clean-up goals have been reached. The potentially responsible party (PRP) is currently leading site clean-up activities with oversight by EPA (USEPA 2010a).

An overview of the sites along with a map indicating the approximate location of each site is provided in Appendix H.

2.15 Cultural Resources

Evidence of human presence in the Savannah River Basin dates back to approximately 9,500 B.C. Numerous archaeological surveys have been conducted in the region including within the areas impounded by the Duke Energy and USACE reservoirs. Accordingly, a number of archaeological and historic sites are known to exist within the reservoirs and along the shoreline of the reservoirs. While most of these sites do not meet the criteria for inclusion in the National Register of Historic Places, some do and are afforded protection under the National Historic Preservation Act. Sites that are determined potentially eligible or requiring additional investigation are treated as though they are eligible until further work has determined concerning their National Register status. The National Historic Preservation Act requires federal agencies like the USACE and FERC to take into account the effects of their undertakings on historic properties, evaluate the effects of their actions on sites eligible for inclusion in the National Register of Historic Places, and provide the Advisory Council on Historic Preservation (ACHP) with a reasonable opportunity to comment on such proposed actions. In addition, Federal agencies are required to consult on the Section 106 process with State Historic Preservation Offices (SHPO), Tribal Historic Preservation Offices (THPO), Indian Tribes (to include Alaska Natives) [Tribes], and Native Hawaiian Organizations (NHO).

In 2006, the USACE issued the "Final Environmental Assessment, Finding of No Significant Impact, Drought Plan Update for the Savannah River Basin" (USACE 2006). In preparing the Drought Plan Update, the USACE reviewed the findings of previous archaeological surveys within the impounded areas of the JST, RBR and Hartwell reservoirs, associated upland areas, and downstream river reaches. USACE consulted with 19 Native American tribes about the proposed Drought Plan Update and a letter indicating concurrence with no adverse impacts was received from the Alabama-Quassarte Tribal Town. The Catawba Indian Nation stated they were opposed to illegal artifact hunting at times of low water but did not indicate any adverse effects. Limited archaeological surveys of areas affected by operation of the USACE projects had been conducted; however, the number of potentially significant prehistoric and historic resources within the fluctuation zone, riverbank or channel, and are adversely affected by changing pool elevations is not completely known.

USACE also consulted with the Augusta Canal Authority, Georgia, and South Carolina State Historic Preservation Officers (SHPO) and 18 Native American Tribes during the agency and public comment period for the 2006 FONSI. The Augusta Canal Authority indicated that flows <3,000 cfs would negatively affect the use of the Augusta Canal (designated by Congress as one of 18 National Heritage Areas in 1996) for recreational purposes, as well as operation of the Petersburg Tour Boats.

USACE performed similar evaluations and consultations for the 2011 Level 4 Drought Operations Study and the 2012 Drought Plan Update. The EA for the Level 4 Study identified the potential for impacts to archaeological and historic sites from extremely low pool levels and river flows. As a result, USACE included a Draft Programmatic Agreement (USACE PA) to identify and address those potential impacts in the Final 2011 Level 4 EA. The PA specifies USACE actions to assess the effects of reservoir operations and downstream flow release on archaeological and historic sites (USACE 2012a). In 2012, USACE consulted with the Georgia and South Carolina SHPOs, the Advisory Council on Historic Preservation (ACHP), and interested Native American tribes regarding potential impacts to historic properties associated with implementation of the updated Drought Plan. USACE drafted a PA which stipulates Savannah District and the Consulting Parties shall identify the need for and scope of, archeological surveys of areas that are affected by changes in lake elevations.

In 2007, FERC consulted with the Advisory Council on Historic Preservation and the South Carolina SHPO regarding potential effects to historic properties associated with implementation of Duke Energy’s SMP at Lake Keowee. Duke Energy, the Catawba Nation, the Cherokee Nation of Oklahoma, and the Eastern Band of Cherokee Indians participated in the consultation and were invited to concur with a Programmatic Agreement (Duke Energy PA), which was executed on May 9, 2007. The agreement outlines stipulations including the acquisition of baseline data on historic properties and development of a predictive model for historic properties.

The PA also lists activities exempt from further review. The Duke Energy PA terminates with issuance of the next FERC License, at which point it will likely be replaced with a new Duke Energy PA requiring Duke Energy implement a Historic Properties Management Plan for the protection of historic properties included in its Application for New License.

Duke Energy surveyed the shoreline of Lake Jocassee, Lake Keowee, islands at both reservoirs, and Keowee-Toxaway access areas during implementation of the Duke Energy PA. Three archaeological sites that may be eligible for inclusion in the National Register of Historic Places were located along Lake Keowee shoreline (Duke Energy 2011). Management of these sites will be addressed in Duke Energy's Historic Properties Management Plan.

At this time, the effects that fluctuating water levels have already had on cultural resources, as well as potential impacts from future changes in water control management are not precisely known. However, the wording of the USACE PA and Duke Energy's PA are sufficiently broad that implementation of those agreements would adequately address such effects.

3.0 OPERATING ALTERNATIVES AND MODELING RESULTS

3.1 Operating Alternatives

During a series of Keowee-Toxaway Relicensing meetings between September 2012 and May 2013, the Stakeholder Team discussed and reviewed many potential reservoir operating regimes (or alternatives). Three of these alternatives and two additional operating alternatives are evaluated in this Environmental Assessment. The five alternatives (introduced in Section 1.3) are described in greater detail below. Note that some of the alternatives include provisions to enhance drought tolerance in the Upper Savannah River Basin. Those measures include enhanced coordinated drought response, measures to protect the Upper Savannah River Basin water supply, and provisions of the Keowee-Toxaway RA. Some of the drought tolerance measures are not captured in the HEC-ResSim model logic or results.

Several of these drought tolerance measures are based on Duke Energy's drought response experience in the Catawba-Wateree River Basin. For example, during the 2007 – 2009 drought of record, nearly two dozen Catawba-Wateree water partners and civic leaders in North and South Carolina issued a unified call for water conservation. Some of the water conservation measures were mandatory (e.g., Charlotte-Mecklenburg Utilities in North Carolina), while others were encouraged, but not mandatory. Regional water conservation efforts resulted in lower water usage and no communities in the basin ran out of water. Charlotte, North Carolina water users played a key role by lowering their water use by as much as 37 percent. Just as importantly, when drought restrictions were lifted in April 2009, water usage remained below pre-drought levels, indicating the communities learned from the experience and voluntarily adopted water conservation measures that extended after the drought measures were lifted. The drought response measures incorporated in A1, A2, A3, and A4 are based, in part, on drought responses measures used in the Catawba-Wateree River Basin.

To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor, each action alternative includes a provision where USACE and Duke Energy would discharge 200 cubic feet per second of water above that specified in the 2012 Drought Plan from their dams for 11 days when the USACE reservoirs are in drought status during the summer months.

A detailed description of the five alternatives evaluated in this EA is provided below.

No Action Alternative (NAA)

The NAA represents the base condition from which the effects of potential changes are evaluated. In this case, the NAA consists of USACE and Duke operating in accordance with the 1968 Agreement (a legally binding document), with no changes. The 1968 Agreement uses the concept of equalizing the percent of combined remaining usable storage capacity at the USACE Hartwell and JST Lakes with the percentage of combined remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee. Throughout the year, USACE calculates that storage on a weekly basis to determine required water releases (or non-release) from Lake Keowee for the upcoming week. The storage balance evaluation to determine the required water release from Lake Keowee is evaluated on a daily basis in the HEC-ResSim model resulting in a daily release representative of the actual weekly release volume requirement.

The 1968 Agreement is based on the reservoir storage between the minimum reservoir elevation and the rule curve for each reservoir. These elevations are provided in Table 3.1-1.

Table 3.1-1 Minimum Reservoir Elevation Levels

Reservoir	Minimum Elevation (feet AMSL)
Lake Jocassee (1)	1,086
Lake Keowee	778
Hartwell Lake	625
JST Lake	312

[1] Plus the volume reserved for pumping (41,000 ac-ft) per the 1968 Agreement, resulting in an operational minimum of 1,080 ft AMSL

The NAA assumes that if the pool elevation within Lake Keowee falls below 793 ft AMSL, Duke would cease to operate the ONS until the pool rises above that elevation. That assumption is based on NRC requirements for operation of the ONS. The NAA incorporates the July 2012 USACE Drought Plan operating protocols as described in Section 3.3.3.

Alternative 1 (A1)

For A1, Duke Energy would modify the ONS so they could operate that facility down to a Lake Keowee pool elevation of 778 ft AMSL. A1 incorporates the USACE July 2012 DP operating protocols. A1 is based on the concept of equalizing the percentage of combined remaining usable storage capacity at the USACE's Hartwell and JST Lakes with the percent of combined remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee.

A1 includes the following provisions to enhance drought tolerance in the Upper Savannah River Basin:

- USACE will require any owner of a Large Water Intake (i.e., water intake with a maximum capacity greater than or equal to one million gallons per day) who is allocated water from the USACE Projects after the Effective Date of the NOA to implement coordinated water conservation measures when the DP is in effect similar to the water conservation measures required by the LIP for Large Water Intake owners on the Duke Energy Projects. Duke Energy will require owners of Large Water Intakes on the Duke Energy Projects to comply with the LIP.
- USACE and Duke Energy will encourage all water users withdrawing water from their respective reservoirs to conserve water in a coordinated manner when the DP is in effect similar to the water conservation measures required by the LIP on Duke Energy Projects.
- USACE and Duke Energy will require whenever feasible that all Large Water Intakes used for municipal, industrial and power generation purposes that are constructed, expanded or rebuilt on the USACE Projects and the Duke Energy Projects after the Effective Date of the NOA be capable of operating at their permitted capacities at reservoir elevations as low as the applicable hydroelectric station can operate.

A1 was not modeled because it is hydraulically identical to the NAA.

Alternative 2 (A2)

A2 represents how Duke Energy has operated the Keowee-Toxaway Project since the mid- to late-1990s during droughts. The overall methodology used to determine required weekly water releases from Lake Keowee remains the same as in the NAA. However, the operational minimum reservoir elevation at Lake Keowee would increase from 778 ft AMSL to 794.6 ft AMSL (resulting from the 1973 NRC requirements for continued operation of the ONS). The minimum reservoir elevation used in the weekly storage balancing calculations remains at 778 ft AMSL for Lake Keowee (as in the 1968 Agreement). Reservoir water withdrawals and evaporation may result in the Lake Keowee elevation falling below the operational minimum of 794.6 ft AMSL, but only to the extent there is minimal additional storage remaining in Lake Jocassee.

As with the NAA, A2 incorporates the July 2012 USACE Drought Plan operating protocols. A2 also equalizes the percent of combined remaining usable storage capacity at the USACE's Hartwell and JST Lakes with the percent of combined remaining usable storage capacity at Duke Energy's Lakes Jocassee and Keowee. A2 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1.

Alternative 3 (A3)

While the NAA's overall concept of balancing the percent of combined remaining usable storage between the Duke Energy and USACE Reservoirs is unchanged in A3, A3 incorporates updated storage volumes, coordinated drought response, measures to protect Upper Savannah River Basin water supply, and Duke's 2013 Keowee-Toxaway Relicensing Agreement. As with the NAA and A2, A3 incorporates the USACE July 2012 Drought Plan operating protocols.

For A3, Duke Energy would modify the ONS to enable them to continue to operate that facility when Lake Keowee elevations drop below 794.6 ft AMSL. With this alternative, the Lake Keowee minimum elevation for calculation of usable storage would be revised to 790 ft AMSL, which allows a 10-foot drawdown of Lake Keowee. The Lake Jocassee minimum reservoir elevation would be lowered six feet (from 1086 ft AMSL to 1080 ft AMSL) and the allowance for pumping volume would be eliminated in the weekly release calculation. A3 incorporates additional reservoir storage created by the USACE and Duke Energy since the 1968 Agreement, through the addition of the Bad Creek Reservoir and RBR Lake, for the purposes of determining the remaining usable storage and weekly water releases from Lake Keowee. Therefore, A3 would equalize the percent of combined remaining usable storage capacity at the USACE's Hartwell, RBR, and JST Lakes with the percentage of combined remaining usable storage capacity at Duke Energy's Bad Creek reservoir and Lakes Jocassee and Keowee.

Details of these changes to minimum reservoir elevations and additional storage capacity in A3 are:

- Addition of storage capacity in USACE's RBR Lake. The RBR storage is calculated as being from elevation 475 ft AMSL (top of conservation pool) to elevation 470 ft AMSL; 126,864 ac-ft of water.
- Addition of storage capacity in Duke Energy's Bad Creek Project. The Bad Creek storage is from elevation 2,310 ft AMSL to 2,150 ft AMSL; 30,229 ac-ft of water.
- Revising the Lake Keowee minimum elevation for calculating usable storage from elevation 778 ft AMSL to elevation 790 ft AMSL, based on Duke modifying the ONS so they can operate that facility down to a Lake Keowee at elevation 790 ft AMSL. The usable storage in Lake Keowee for the purpose of this Agreement would decrease from 327,766 ac-ft (at 778 ft AMSL in the 1968 Agreement) to 161,772 ac-ft (at 790 ft AMSL).

A3 includes the following provisions to enhance drought tolerance in the Upper Savannah River Basin:

- The same drought tolerance provisions included in A1. Those provisions include Duke Energy implementing the Keowee-Toxaway LIP which describes how the Duke Energy Reservoirs would be operated during periods of drought, including minimum reservoir elevations and water use conservation for varying levels of drought severity (and closely follows the USACE's DP). Details of the Keowee-Toxaway LIP are provided below:
    - LIP Stage minimum elevations for Lake Jocassee and Lake Keowee (respectively)
        - Stage 0: 1,096 ft AMSL; 796 ft AMSL

- Stage 1: 1,092 ft AMSL; 795 ft AMSL
- Stage 2: 1,087 ft AMSL; 793 ft AMSL
- Stage 3: 1,083 ft AMSL; 792 ft AMSL
- Stage 4: 1,080 ft AMSL; 790 ft AMSL

- In LIP Stage 4, the Lake Keowee elevation is maintained at or above 791.5 ft AMSL until Duke Energy's remaining usable water storage drops to 12 percent, at which time non-emergency or non-ONS-related intentional flow releases are stopped and the minimum elevation is allowed to drop to the Stage 4 minimum elevation of 790 ft AMSL due to natural surface evaporation, on-lake water withdrawals, dam seepage, and hydro unit leakage. At least 650 ac-ft of water per week continues to be released via hydro unit leakage and dam seepage from the Keowee Development into Hartwell Lake.
- The LIP for this scenario allows Lake Keowee to move more quickly to a less severe drought level during the recovery process by eliminating the 2-foot recovery delay in the USACE's DP operating protocols. This does not impact the USACE's DP levels for Hartwell Lake and JST Lake.

- Duke Energy would provide $438,000 to support Phase 3 of the USACE's Savannah River Basin Comprehensive Study (i.e., consideration of reallocating flood storage).

A3 includes a provision to address adverse impacts to recreational users of the USACE reservoirs. Duke Energy would provide funding and/or in-kind services to USACE and other public entities to improve public boating access at Hartwell and Thurmond Reservoir facilities to fully mitigate for adverse impacts to recreational access to those reservoirs. Those impacts are presently estimated to be $2,938,000 (FY14 price levels) over a 50-year evaluation period.

A3 also includes the following provision to avoid adverse impacts to dissolved oxygen levels in Savannah Harbor: USACE and Duke Energy would discharge 200 cubic feet per second of water above that specified in the 2012 Drought Plan from their dams for 11 days when the USACE reservoirs are in drought status during the summer months.

Alternative 4 (A4)

A4 is included to evaluate how LIP operations (described in A3) affect Duke and USACE reservoir levels. A4 includes the same reservoir usable storage updates as A3 and requires Duke to modify the ONS so they could operate it down to a Lake Keowee elevation of 790 ft AMSL. A4 does not include the Keowee-Toxaway Project LIP provisions found in A3. The exclusion of those provisions in the Duke system in A4 is the only difference between A3 and A4.

As with the other alternatives, A4 incorporates the USACE July 2012 Drought Plan operating protocols. A4 equalizes the percent of combined remaining usable storage capacity at the USACE's Hartwell, RBR, and JST Lakes with the percent of combined remaining usable storage capacity at Duke Energy's Bad Creek reservoir and Lakes Jocassee and Keowee. A4 includes the same provisions to enhance drought tolerance in the Upper Savannah River Basin as A1. A4 includes Duke Energy's support of Phase 3 of the USACE's Savannah River Basin Comprehensive Study through $438,000, as well as the funding identified in A3 to address adverse impacts to recreational users of the USACE reservoirs.

3.2 Duke Energy System Water Availability

As described in Section 3.1, USACE calculates reservoir storage on a weekly basis for the USACE and Duke Energy systems and identifies the flow releases required from the Keowee Hydroelectric Station. Figure 3.2-1 provides a graphical representation of the volume of water available for use from the Keowee-Toxaway and Bad Creek Projects for each of the alternatives as the percentage of remaining storage in the USACE system declines (uses include municipal water withdrawals from Lake Keowee, ONS project uses, and flow releases to the USACE reservoirs). The volume of water available for use under the NAA and A1 is the same, thus they are represented by a single line in Figure 3.2-1. The volume of water available for use under A3 and A4 is also similar and is depicted by a single line.

The graphs shown in Figure 3.2-1 are conceptual and not based on HEC-ResSim model results. However, they provide insight as to how much water is available for use from the Duke Energy system based on USACE system storage levels. The results assume that inflows to the Duke

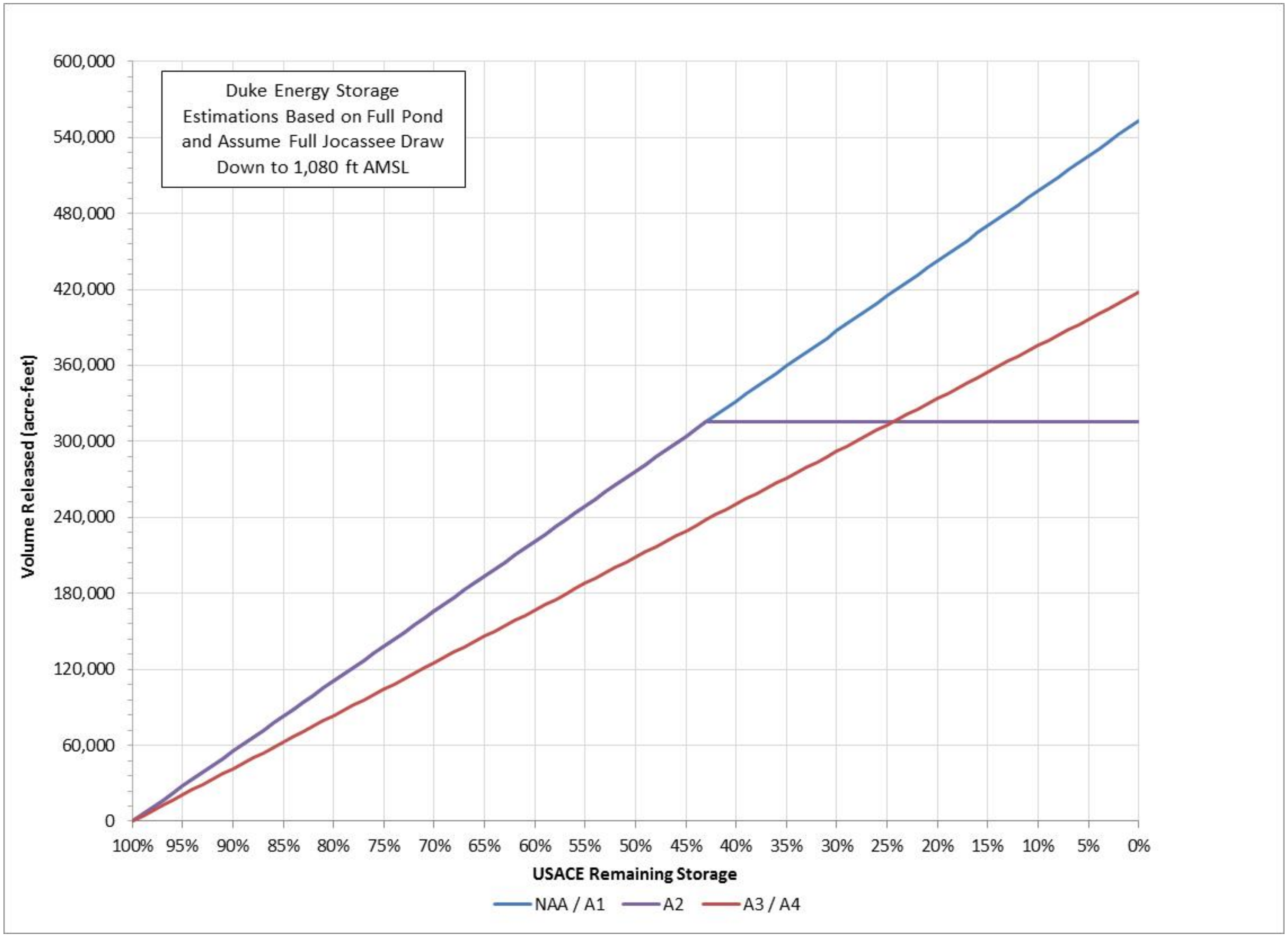
Energy system is enough to offset natural and forced evaporation, on-lake water withdrawals, dam and hydro unit leakage, and groundwater seepage at the three reservoirs in the Duke Energy system.

Among the five alternatives, the NAA and A1 have the largest volume of water available for use from Lake Keowee, since the reservoir elevation for these two alternatives is allowed to drop to 778 ft AMSL.

A2 assumes no flow release is made from Lake Keowee if that release would result in the reservoir dropping below 794.6 ft AMSL (results also assume Lake Jocassee is kept near 1086 ft AMSL and Bad Creek Project storage is not available). Figure 3.2-1 indicates no water is available to be released from the Duke Energy system in A2 once the USACE system storage drops below approximately 43 percent.

While less water is available for use in A3 and A4 when the USACE system storage is between 100 and 25 percent compared to the NAA, A1, and A2, more water is available for use than in A2 when USACE system storage levels drop below 25 percent during severe droughts. There would be less water available for use in A2, A3 and A4 when USACE system storage levels drop below 43 percent when compared to the NAA.

Figure 3.2-1 Duke Energy Cumulative Water Volume Used Based on USACE Percent Remaining Usable Storage



3.3 HEC-ResSim Model Development

For purposes of identifying and evaluating differences between the alternatives, Duke used the USACE HEC-ResSim model to simulate reservoir elevations and flow releases below JST Lake for each of the four alternatives over a 73-year period of record (POR) (1939–2011). Note that A1 is the same as the NAA for modeling purposes and does not require a separate hydrologic model simulation.

3.3.1 *HEC-ResSim Model Development*

USACE previously developed a HEC-ResSim model for its three reservoir projects on the Savannah River (i.e., Hartwell Lake, RBR Lake, and JST Lake). The original model setup included general features associated with Duke Energy's Lakes Jocassee and Keowee such as drainage areas, reservoir volumes, general operating rules, and flow releases from each development. In order to model the four alternatives more accurately and enable Duke to use the model in conjunction with their relicensing efforts for the Keowee-Toxaway Project, Duke Energy refined the model for Lakes Jocassee and Keowee, and added Bad Creek to the model logic. These refinements include more detail on reservoir operating rules for high water management and water conservation modes of operation, additional logic on pumped storage operations at Jocassee Pumped Storage Station, and derived UIF to each reservoir. These refinements also include known and calculated water withdrawals from each reservoir, including the estimated current (Year 2010) and projected future (Year 2066) water withdrawals from (and returns to) each reservoir for all registered water use entities. Appendix A summarizes the present water use volumes and future water use projections that were used in the analysis.

3.3.2 *Hydrology Development*

The UIF previously used in the HEC-ResSim model was developed by ARCADIS for the GA DNR-EPD (September 2010) and had a POR extending from 1939 through 2007. That UIF treated hydrology from the upper portions of the Savannah River Basin (i.e., the Duke Energy reservoir areas) as a lump sum. To refine the UIF to incorporate the historic operations of the Duke Energy facilities, historic hard copy reservoir operations records for Bad Creek, Lake

Jocassee, and Lake Keowee were digitized and incorporated into the 1939–2007 hydrology database. ARCADIS subsequently added 2008 hydrology to the UIF.

Duke revised and enhanced the HEC-ResSim model to support the evaluations in this EA. At the same time, they retained HDR Engineering (HDR) to develop a CHEOPS hydrologic model to support the Keowee-Toxaway Relicensing effort. To maintain consistency between the two hydrologic models, the PDT and the relicensing Stakeholder Team recommended using the same hydrology database developed by ARCADIS in both models. That stakeholder team provided advice during the development of the hydrologic modeling. During the analysis, ARCADIS extended the hydrology database through 2011, providing a 73-year POR (1939 – 2011).

3.3.3 *USACE Drought Plan*

Savannah District had developed a Short-Range Drought Water Management Strategy in 1986 to address the water shortage conditions in the Savannah River Basin at that time. This strategy served as a guide for using the remaining storage in the USACE-operated reservoirs and later became a timely foundation for a long-term strategy to deal with the 1988 drought and other severe droughts going forward (USACE 2012a). During the drought of 1988, JST and Hartwell Lakes dropped to almost 17 feet and 15 feet, respectively, below the top of their conservation pools (normal operating range). As a result, the USACE was not able to fully meet the authorized project purposes of hydropower and recreation. Subsequently, USACE developed the initial Drought Plan in 1989 to establish three reservoir elevation trigger levels (USACE 1989). The trigger levels are based on the reservoir elevations at both Hartwell and JST Lakes.

USACE developed the Savannah River Basin DP to help balance impacts to the authorized uses of its three reservoir projects during times of insufficient rainfall. To reduce the decline in pool elevations during the early stages of a drought, USACE reduces weekly average flow releases from the Hartwell and JST Projects. Once the DP has been activated, maximum flow amounts are reduced in a step-wise fashion from JST Lake. Reservoir elevations at the Hartwell and JST Projects are kept in balance during non-drought and the early levels of droughts.

In 2006, the DP was revised to include a fourth trigger level. The 2006 DP allowed the USACE to maintain higher pools at the reservoirs without further impacting water intakes upstream or downstream of the dams. Table 3.3-1 provides the flood control, conservation, and minimum conservation pool elevations for Hartwell, RBR, and JST Lakes.

Table 3.3-1 Flood Control, Conservation, and Minimum Conservation Pool Elevations for Hartwell, RBR, and JST Reservoirs

Pool Elevation	Hartwell Lake (feet AMSL)	RBR Lake (feet AMSL)	JST Lake (feet AMSL)
Top of Flood Control	665	480	335
Top of Conservation Pool (Summer/Winter)	660/656	475	330/326
Minimum Conservation Pool	625	470	312

Source: USACE 2010c

The 2012 revision to the DP reduced minimum flow releases below JST Lake and added a reservoir inflow trigger for the Broad River tributary (based on reported flows at the USGS Gage 02192000 Broad River near Bell, Georgia). Table 3.3-2 provides the seasonal trigger levels and management action (i.e., minimum required flow release from JST Lake).

Each drought level requires a minimum daily average flow release from JST Lake. The required flow release in the DP for Level 1 is 4,200 cfs when Broad River inflows, as reported by the USGS, are greater than 10 percent of the historical flow rate (calculated over a 28-day average); the required flow release drops to 4,000 cfs when Broad River inflows drop to less than or equal to 10 percent of the historical flow rate. The required flow release from JST for DP Level 2 is 3,600 cfs from November through January regardless of inflows. During the period February through October, the required flow release in DP Level 2 is 4,000 cfs when Broad River inflows are greater than 10 percent of the historical flow rate; the required flow release drops to 3,800 cfs when Broad River inflows are less than or equal to 10 percent of the historical flow rate.

Drought Levels 3 and 4 are not linked to inflows from the Broad River and are solely based on Hartwell and JST Lake elevations. Minimum required flow releases from JST for Levels 3 and 4 for the period February through October are 3,800 cfs and 3,600 cfs, respectively (and are reduced to 3,100 cfs from November through January). Those releases from JST would be continued during Level 4 for as long as possible; then they would be reduced to equal reservoir inflows.

Table 3.3-2 Hartwell and JST Lake Seasonal Trigger Levels

Trigger Level	1 Apr–15 Oct (feet AMSL)		15 Dec–1 Jan (feet AMSL)		Action
	Hartwell Lake	JST Lake	Hartwell Lake	JST Lake	
1	656	326	654	324	If Broad River inflows > 10% of historical flow rate, set JST Lake outflow to 4,200 cfs. If Broad River inflows <= 10% of historical flow rate, set JST Lake outflow to 4,000 cfs.
2	654	324	652	322	If Broad River inflows > 10% of historical flow rate, set JST Lake outflow to 4,000 cfs. If Broad River inflows <= 10% of historical flow rate, set JST Lake outflow to 3,800 cfs. Set JST Lake outflow to 3,600 cfs November through January.
3	646	316	646	316	Set JST Lake outflow to 3,800 cfs. Set JST Lake outflow to 3,100 cfs November through January.
4	625	312	625	312	Set JST Lake outflow to 3,600 cfs. Set JST Lake outflow to 3,100 cfs November through January. Continue release as long as possible, then outflow = inflow.

Note: Inflow is measured at the Broad River near Bell, Georgia USGS flow gaging station (#02192000)
Source: USACE 2012a

The 2012 DP includes the potential for adaptive management when USACE reduces flows from the JST Project during the months of November, December and January. As adaptive management, USACE would restore the 3,800/3,600 cfs release from the JST Project if requested by a state regulatory agency in Georgia and/or South Carolina to support downstream water quality, including in the Savannah Harbor. As a result, adaptive management flow releases could be implemented during DP Levels 2, 3, and/or 4.

If implemented, adaptive management flow releases would be made during the November to January timeframe and would involve increasing the JST flow release from the minimum allowed during those months. For example, if adaptive management were implemented during Level 3 conditions, the minimum JST Project flow release would be raised from 3,100 cfs, in an unspecified step-wise fashion, up to 3,800 cfs for the months of November, December and

January. The minimum required flow release for February through October would remain unchanged at 3,800 cfs.

3.3.4 *HEC-ResSim Model Verification*

Once Duke updated the HEC-ResSim model with more detailed information for its Projects, and the inflows from the extended UIF were incorporated, model results were verified using several different methods.

First, HEC-ResSim model output was compared to historical reservoir elevations, generation, and flow releases from each project. The results of this comparison are provided in Appendix I. Overall, the model outputs for each of the four scenarios, while not exact, offer a very good representation of reservoir elevations, generation, and flow releases from each project. As summarized in Appendix I, the HEC-ResSim model adequately represents the Savannah River Basin from Bad Creek downstream to the outlet of JST Lake.

Second, HEC-ResSim model output was compared to CHEOPS model output for the same period of record. The results of this comparison are provided in Appendix J. While there are some minor differences between the two models, they are within the accuracy range of complex hydrologic models.

3.3.5 *HEC-ResSim Model Sensitivity Analysis*

From a modeling perspective each operating scenario was run under a base set of water withdrawal and hydrology assumptions. The base set of assumptions includes projected future water withdrawals (as a constant throughout the POR) along with historic (i.e., unaltered) ARCADIS hydrology for the 1939–2011 POR. The model results using the base set of model assumptions are described in detail in Sections 3 and 4.

In addition, a set of model sensitivity analyses were performed using modified water withdrawal and hydrology assumptions. The first sensitivity analysis incorporated current water withdrawals (as a constant throughout the POR) along with the historic ARCADIS inflow hydrology dataset

(1939–2011 POR). The second set of sensitivity analyses incorporated projected future water withdrawals with climate change hydrology conditions (due to hypothetical climate change estimates) developed by HDR for the 1939–2011 POR. Results from the sensitivity analyses are briefly described in the main body of this document and detailed results are included in the appendices.

In brief, the three sets of water withdrawal and hydrology model assumptions are described below.

- Future water withdrawals (Year 2066) with historic hydrology
- Current water withdrawals (Year 2010) with historic hydrology
- Future water withdrawals (Year 2066) with climate change hydrology

The scenario titled "Future Water Withdrawals" consists of the expected water withdrawals by 2066 by presently-permitted users. To assess possible effects of adverse climatological changes on that issue, the hydrologic modelers considered (1) a 3 degree temperature rise (which would lead to a 10% increase in evaporation) and no reduction in inflows, and (2) a 6 degree temperature rise (which would lead to a 20% increase in evaporation) and a 10% reduction in inflows. The Climate Change hydrology scenario uses the larger changes -- a 6 degree temperature rise (which would lead to a 20% increase in evaporation) and a 10% reduction in inflows.

3.3.6 *Reservoir Sedimentation*

The HEC-ResSim model uses reservoir storage volume curves as input for both the Duke Energy and USACE reservoirs. Storage volumes for Lakes Jocassee and Keowee were based on 2010 bathymetry data; the original USACE reservoir storage capacities were reduced a small amount based on estimated sediment yields and deposition patterns since the reservoirs were constructed. Details regarding the 2010 reservoir storage curves for both the Duke Energy and USACE reservoirs are provided in Appendix L. The estimated reservoir storage capacity losses due to sedimentation through Year 2060 were less than 1 percent and, therefore, were not included in the model scenarios for future years.

3.4 USACE and Duke Energy Storage Balance Model Results

One objective of the HEC-ResSim model is to balance available storage between Duke Energy's reservoirs and the USACE's reservoirs on a daily basis (this is described in the 1968 Agreement on a weekly basis). Figures 3.4-1 through 3.4-4 compare USACE and Duke Energy system storage over the 73-year POR (future water withdrawals with historic hydrology) for the four operating scenarios. These graphs depict results from model runs that include the USACE's 2012 DP, but assume adaptive management (as described in Section 3.3.3) is not implemented. A summary of key points is provided below.

- Over the majority of the POR, all four model operating scenarios result in similar available storages (expressed in terms of percent remaining usable storage) between the USACE and Duke Energy reservoirs.
- The USACE and Duke Energy remaining usable storage is greater than 60 percent during the majority of the POR.
- The Duke Energy percent remaining usable storage is typically slightly lower than the USACE percent remaining usable storage over the POR. This is not the case during extreme drought conditions under NAA/A1 and A2 where USACE's remaining usable storage drops below that of Duke Energy's reservoirs. For example, under NAA/A1, the USACE's remaining usable storage drops to 16 percent while Duke Energy's remaining usable storage is slightly higher at 17 percent near the end of the 2007 – 2008 extreme drought. A2 results during this same extreme drought period show the USACE's remaining usable storage drops to 20 percent while Duke Energy's remaining usable storage is 42 percent. In A2, the Lake Keowee volume used in the weekly flow release calculation is the same as the NAA/A1, but no release beyond leakage and seepage is made if it would cause Lake Keowee's reservoir elevation to drop below 794.6 ft AMSL. This results in more Duke Energy remaining usable storage in A2 (compared to NAA/A1) as shown on Figures 3.4-1 and 3.4-2 at the end of the 2007 – 2008 extreme drought.

- Under A3, the USACE's and Duke Energy's remaining usable storage levels are 13 percent and 11 percent, respectively, near the end of the 2007 – 2008 extreme drought.
- Under A4, the USACE's and Duke Energy's remaining usable storage levels are 13 percent and 10 percent, respectively, near the end of the 2007 – 2008 extreme drought.
- While Duke Energy's remaining usable storage drops below 12 percent for a short period under both A3 and A4, a scheduled storage balance weekly release to the USACE system would not be required during this period because the USACE's remaining usable storage is greater than Duke Energy's remaining usable storage.

3.4.1 *Remaining Usable Storage – Sensitivity Analysis*

Appendix K includes figures comparing the remaining usable storage for the USACE and Duke Energy reservoir systems for current water withdrawals with historic hydrology and future water withdrawals with climate change hydrology. Key points from the sensitivity analysis are:

- Overall, results of the sensitivity analysis are similar to those provided in Figures 3.4-1 through 3.4-4 for future water withdrawals with historic hydrology.
- For current water withdrawals with historic hydrology, the lowest USACE remaining usable storage is 24 percent under A2 (the corresponding lowest Duke Energy remaining usable storage is 44 percent under A2). This occurs at the end of the 2007 – 2008 extreme drought. A4 results in the lowest Duke Energy remaining usable storage at 19 percent, also at the end of 2008.
- For future water withdrawals with climate change hydrology, the minimum USACE remaining usable storage is 10 percent under both A3 and A4 (see Figures K-7 and K-8 in Appendix K). These two model scenarios also result in the lowest Duke Energy remaining usable storage at 10 percent and 7 percent for A3 and A4, respectively. Again, these results occur at the end of the 2007 – 2008 extreme drought. Since Duke Energy's remaining usable storage is equal to or less than the USACE's remaining usable storage, a scheduled storage balance weekly release from Keowee Hydroelectric Station would not be required.

Figure 3.4-1 Duke Energy and USACE Reservoir Storage Percentages – NAA/A1 (Future Water Withdrawals with Historic Hydrology (1939–2011))

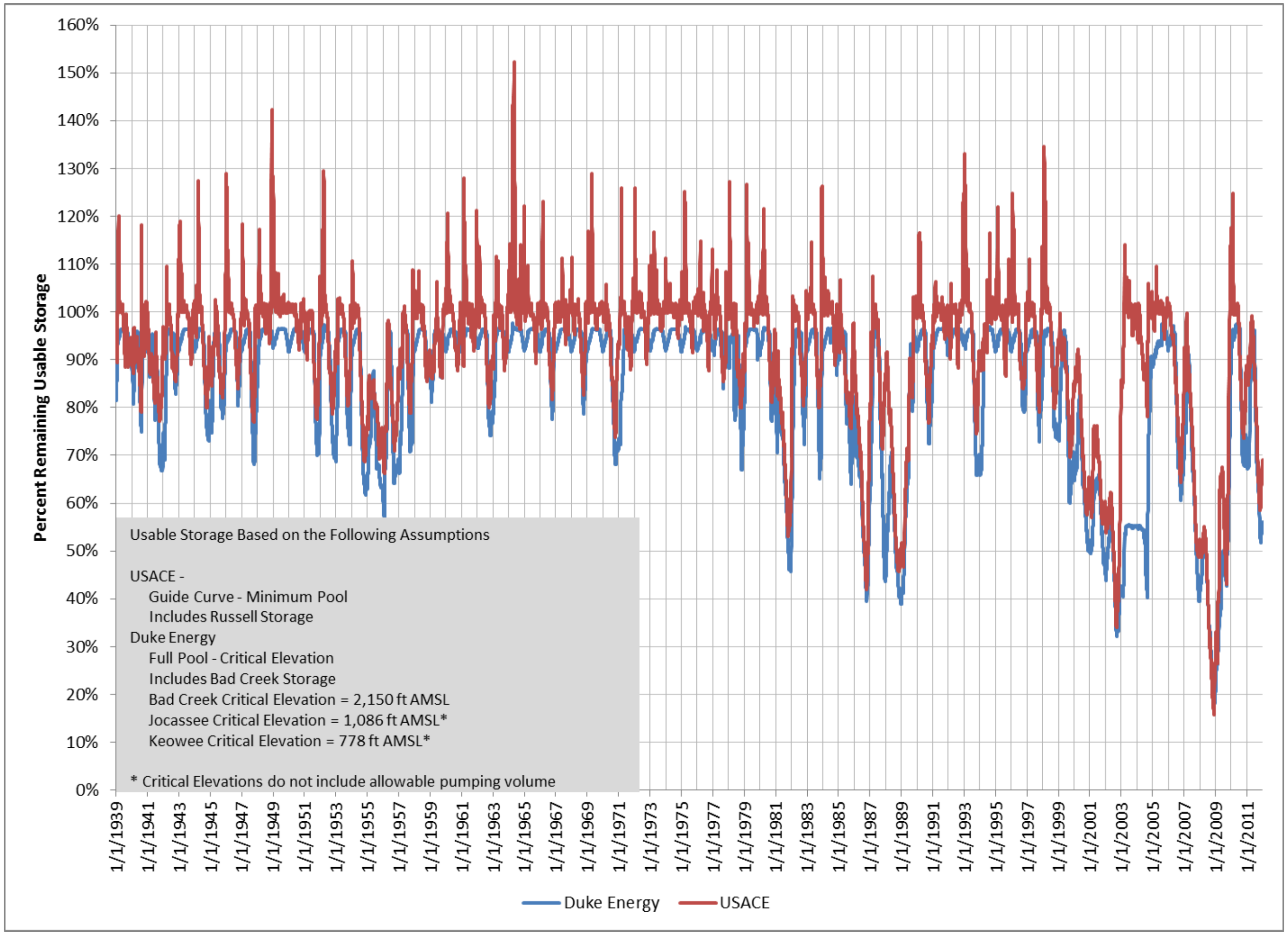


Figure 3.4-2 Duke Energy and USACE Reservoir Storage Percentages – A2

(Future Water Withdrawals with Historic Hydrology (1939–2011))

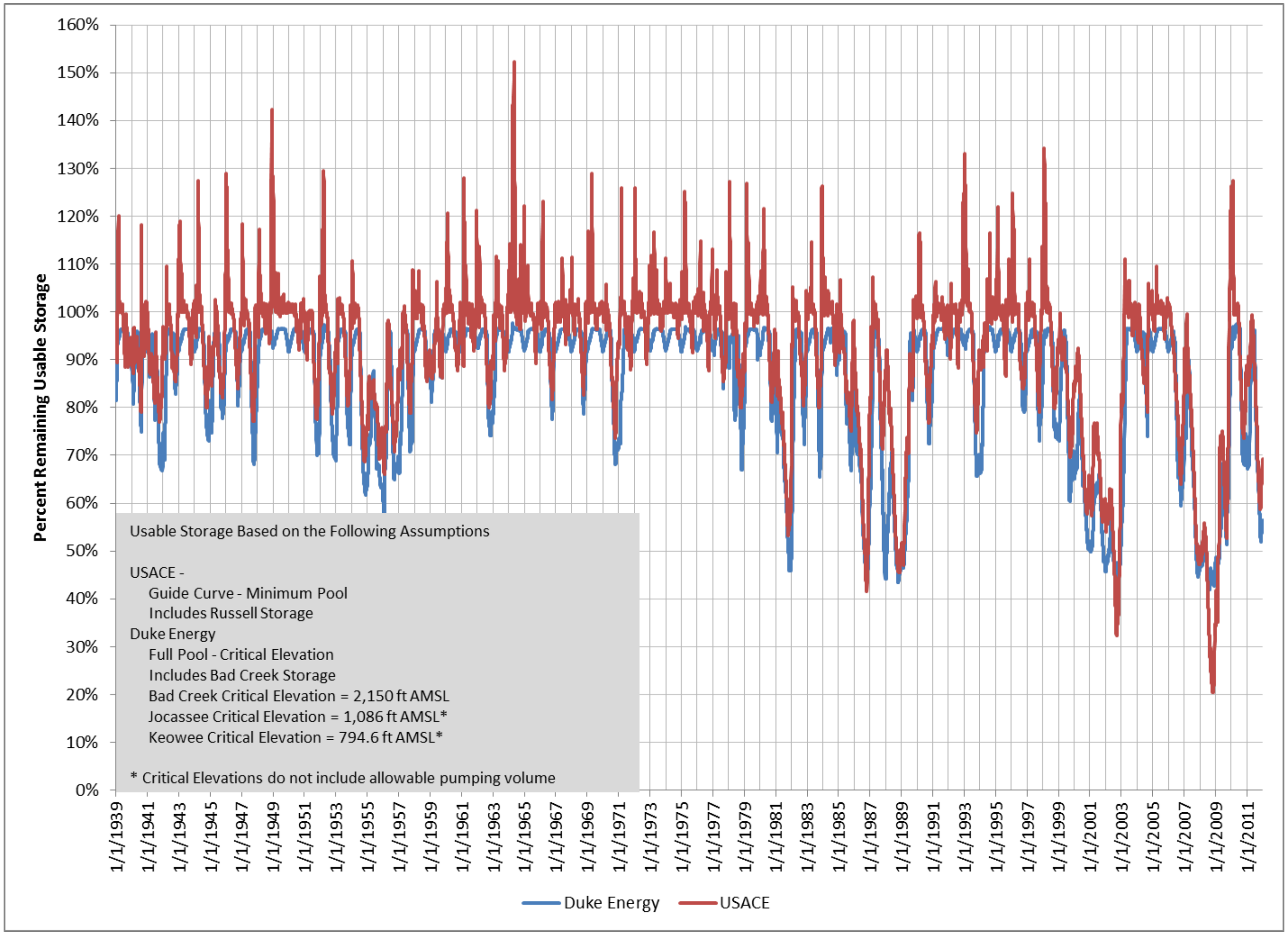


Figure 3.4-3 Duke Energy and USACE Reservoir Storage Percentages – A3

(Future Water Withdrawals with Historic Hydrology (1939–2011))

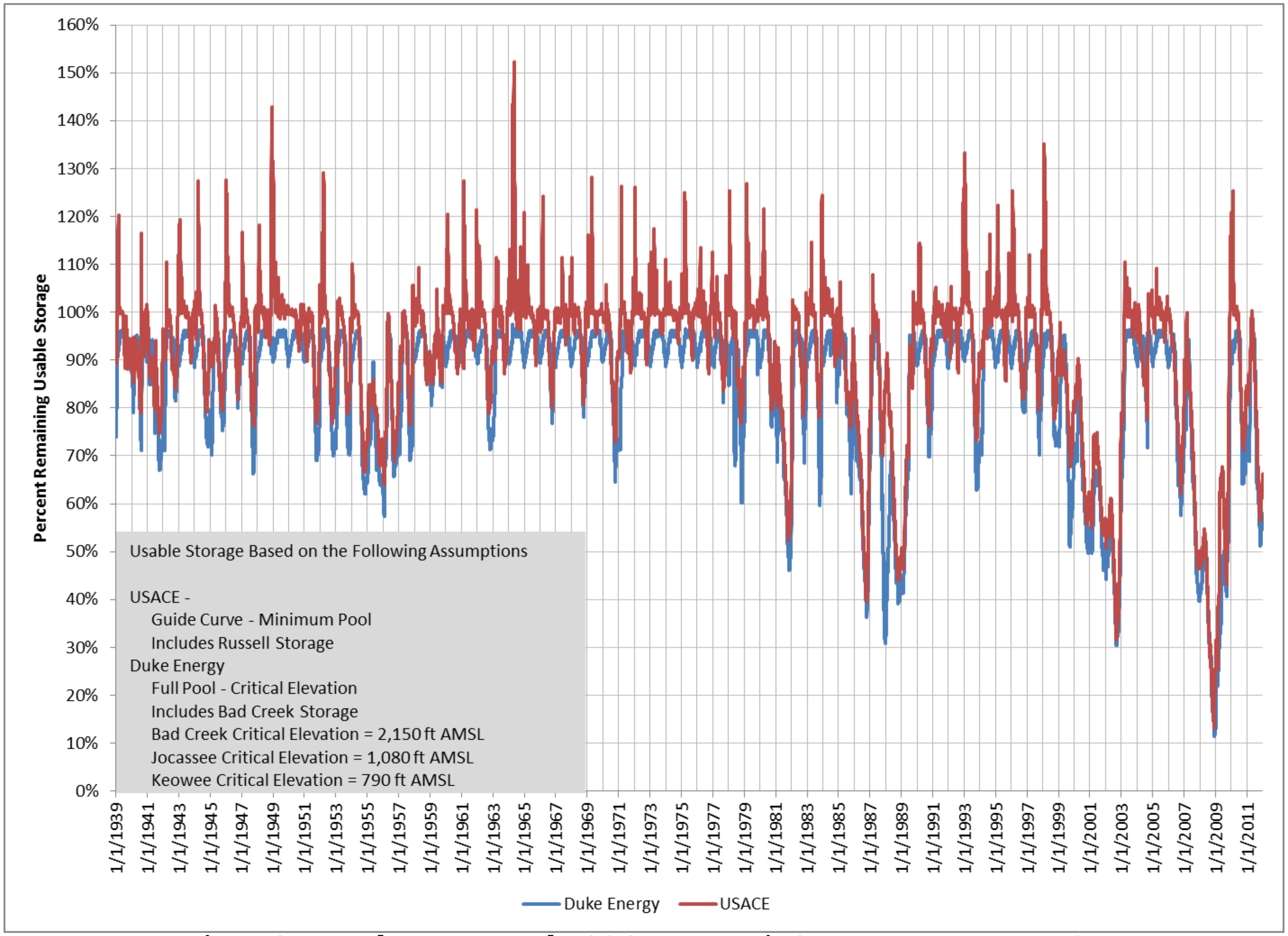
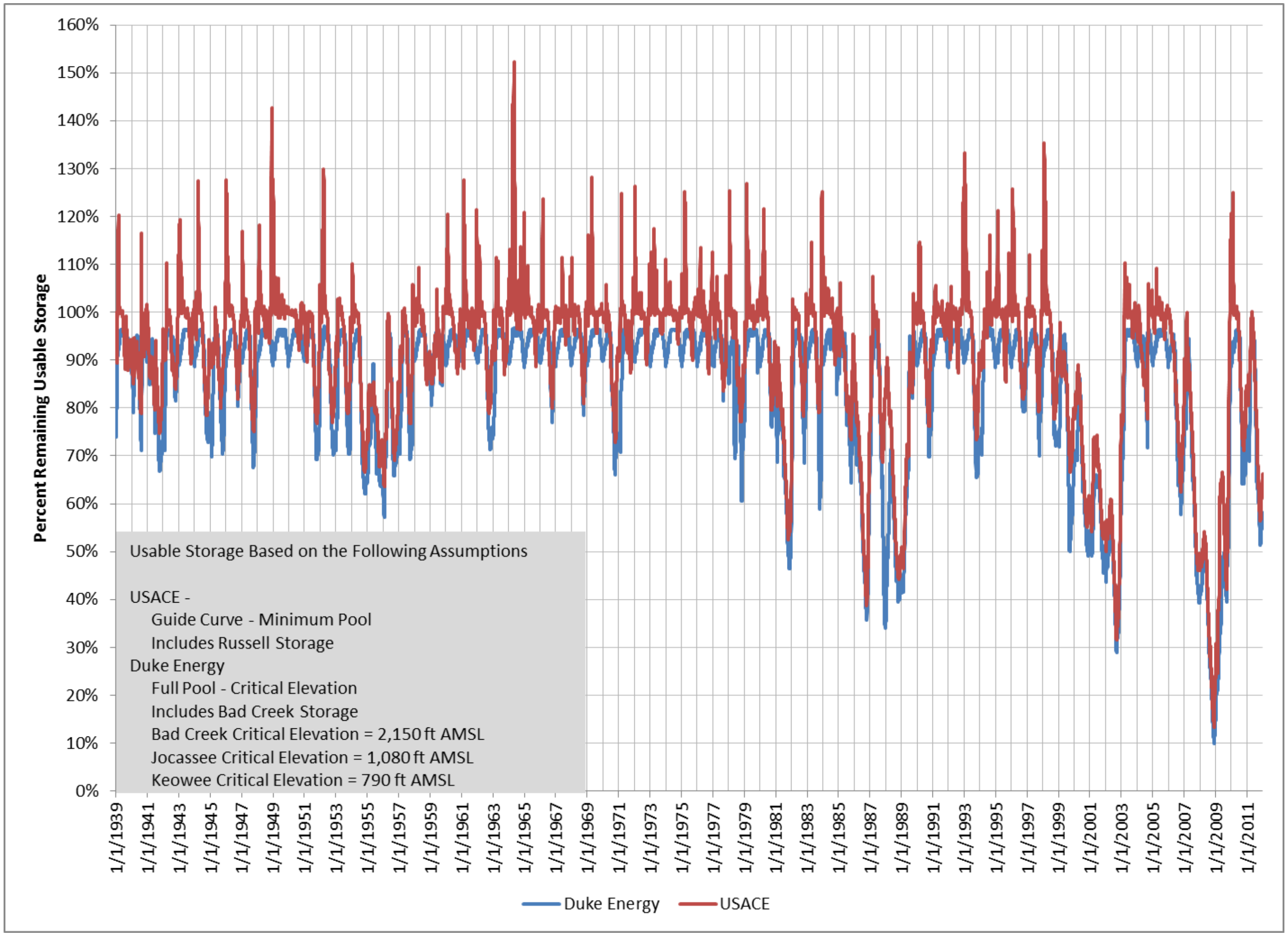


Figure 3.4-4 Duke Energy and USACE Reservoir Storage Percentages – A4

(Future Water Withdrawals with Historic Hydrology (1939–2011))



3.4.2 *Remaining Usable Storage with Adaptive Management*

Figures 3.4-5 through 3.4-8 compare USACE and Duke Energy system storage over the 73-year POR (future water withdrawals with historic hydrology) for the four operating scenarios. These graphs show results from model runs that assume the USACE implements the 2012 DP adaptive management flow releases at the JST Project (as described in Section 3.3.3). The HEC-ResSim model logic was set to not allow JST Project flow releases less than 3,800 cfs during all Level 2 and 3 days (note a Level 4 was never reached in any model scenario or sensitivity analyses). In reality, the USACE could gradually bump the minimum required flow releases up to 3,800 cfs over time. Therefore, setting the minimum JST flow release at 3,800 cfs is a conservative assumption.

HEC-ResSim allows the input of only one storage relationship between the reservoirs (Appendix J), which influences simulated reservoir responses during the deepest part of the drought of 2007 – 2008. Since the USACE facilities are operated with winter drawdowns, the remaining usable storage percentages referenced or used in the HEC-ResSim model during the fall/winter drawdown (October 16 to March 31) are not reflective of the change in the Guide Curve. In other words, during those seasonal drawdowns, the USACE usable storage volume is smaller than the volume assumed by the model. Therefore, the percentage remaining usable storage calculated by the model during this period is smaller than it would be in practice. During normal hydrology periods this difference in storage balance percentages used in the model simulation is not considered significant, but during extended drought periods like 2007 – 2008 where remaining storage volumes are much smaller, this modeling assumption affects the accuracy of the simulated remaining usable storage percentages since the scenario would otherwise require higher releases for the Duke Energy Reservoirs during the October 16 to March 31 period.

A summary of key points is provided below.

- Since adaptive management flow releases only occur if/when JST releases fall below 3,800 cfs (i.e., during Level 2 and 3 droughts), the only differences in remaining usable storage between the USACE and Duke systems occur during extreme droughts (Figures 3.4-1 through 3.4-4).

- A3 and A4 would produce the lowest remaining usable storage for both the USACE and Duke Energy Reservoirs.
- For A3, Duke Energy's remaining usable storage would have fallen below 12 percent for a 44-day period (i.e., October 26 through December 8, 2008) at the deepest part of the 2007 – 2008 extreme drought. At its lowest point, Duke Energy's remaining usable storage would be 9.8 percent while the USACE's would be 8.7 percent. Since Duke Energy's remaining usable storage is less than 12 percent, no scheduled storage balance weekly release from Keowee Hydroelectric Station would occur. However approximately 650 ac-ft per week would be released from Keowee via seepage and leakage.
- For A3, there are five periods in the historical POR that simulate JST releases below 3,800 cfs. If winter adaptive management flow releases were made during these five periods (as described in Section 3.3.3), the resulting drop in reservoir elevation for Hartwell and JST Lakes would be less than 0.4 feet. This assumes the lake elevation decreases are based on equalizing stage change between these two reservoirs.
- For A4, USACE's lowest remaining usable storage was approximately 7 percent, while the lowest remaining usable storage for the Duke Energy System was approximately 5 percent. Since Duke Energy's remaining usable storage is less than the USACE remaining usable storage, no scheduled storage balance weekly release from Keowee would occur.

3.4.3 *Remaining Usable Storage with Adaptive Management - Sensitivity Analysis*

Appendix K contains figures comparing the remaining usable storage for the USACE and Duke Energy reservoir systems for current water withdrawals with historic hydrology and future water withdrawals with climate change hydrology. This sensitivity analysis also assumes winter adaptive management flow releases are made from the JST Project as described in Section 3.3.3.

Key points from the adaptive management sensitivity analysis are:

- For all alternatives, the USACE and Duke Energy reservoirs experience the lowest remaining usable storage percentages under the future water withdrawals with climate change hydrology model scenarios.
- Using climate change assumptions, A3 and A4 result in the lowest remaining usable storage for both the USACE and Duke Energy Reservoir systems. This occurred near the end of the 2007 – 2008 extreme drought (see Figure 3.4-9).
- For A3, there is a 56-day period (October 16 through December 10, 2008) where Duke Energy's remaining usable storage drops below 12 percent. At its lowest point, Duke Energy's remaining usable storage was 8.1 percent while the USACE's remaining usable storage was 7.5 percent. During this period, no scheduled storage balance weekly release from Keowee Hydroelectric Station would occur. However, roughly 650 ac-ft of water per week would continue to leak and seep from the Keowee Development into Hartwell Lake. The HEC-ResSim model does not account for such leakage and dam seepage. As a result, Duke Energy's remaining usable storage during this period may be somewhat less than 8.1 percent and the USACE's average remaining usable storage may be somewhat greater than 7.5 percent. As discussed above, USACE's remaining usable storage percentages calculated by the model for the period October 16 to March 31 may be lower than what would actually occur.
- For A4, the USACE's lowest remaining usable storage was approximately 6 percent, while that for Duke Energy's was approximately 4 percent. Since USACE's remaining usable storage percentage was greater than Duke Energy's during this extreme drought, a water release from the Duke Energy system would not occur under A4.
- Duke Energy's available storage is able to support the USACE's 2012 DP operations, including winter adaptive management flow releases to the lower Savannah River from the JST Project, even under worst case model sensitivity analysis including climate change assumptions.

Figure 3.4-5 Duke Energy and USACE Reservoir Storage Percentages with Minimum JST Flow Release set at 3,800 cfs – NAA/A1 (Future Water Withdrawals with Historic Hydrology (1939–2011))

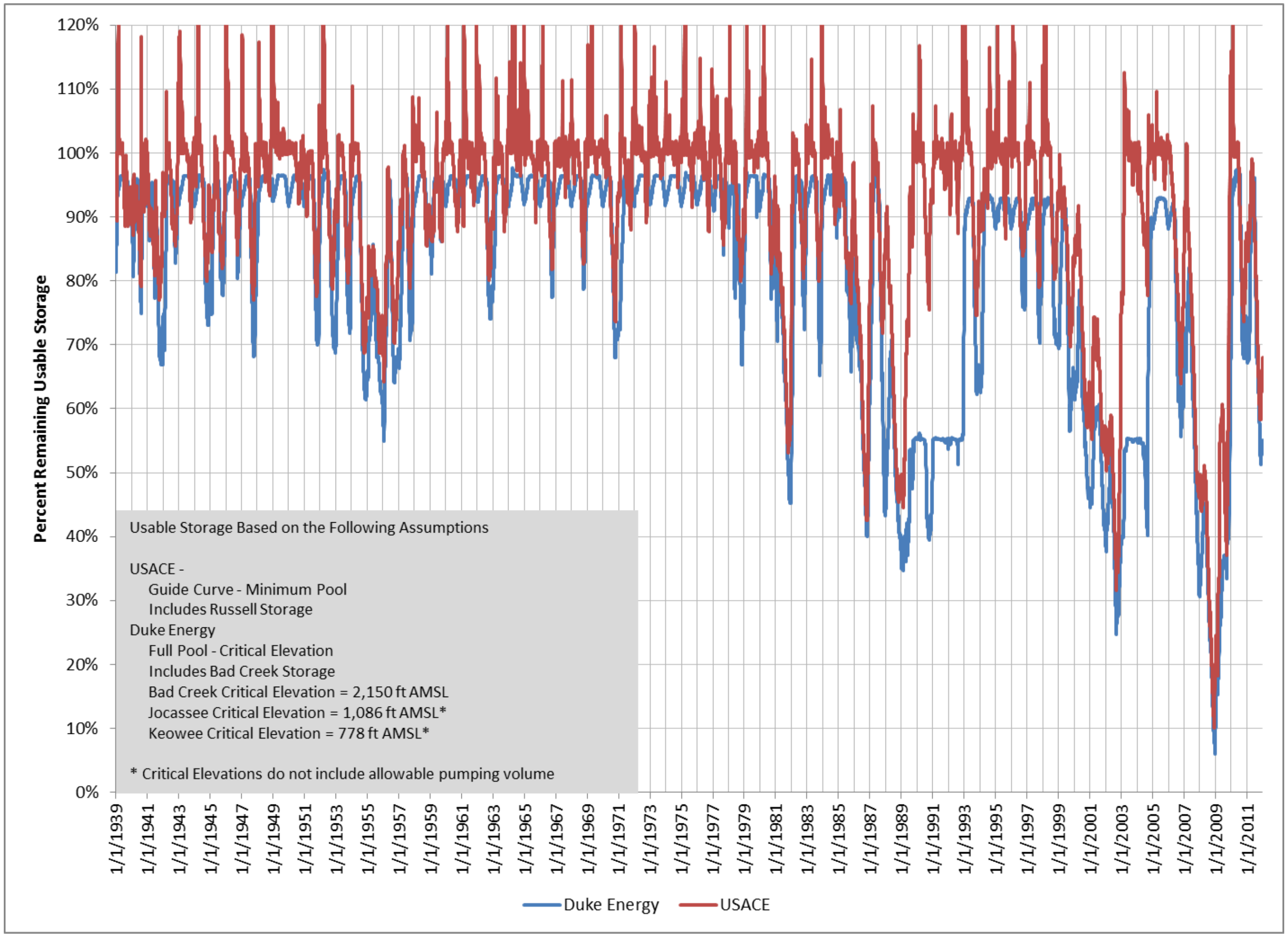


Figure 3.4-6 Duke Energy and USACE Reservoir Storage Percentages with Minimum JST Flow Release set at 3,800 cfs – A2 (Future Water Withdrawals with Historic Hydrology (1939–2011))

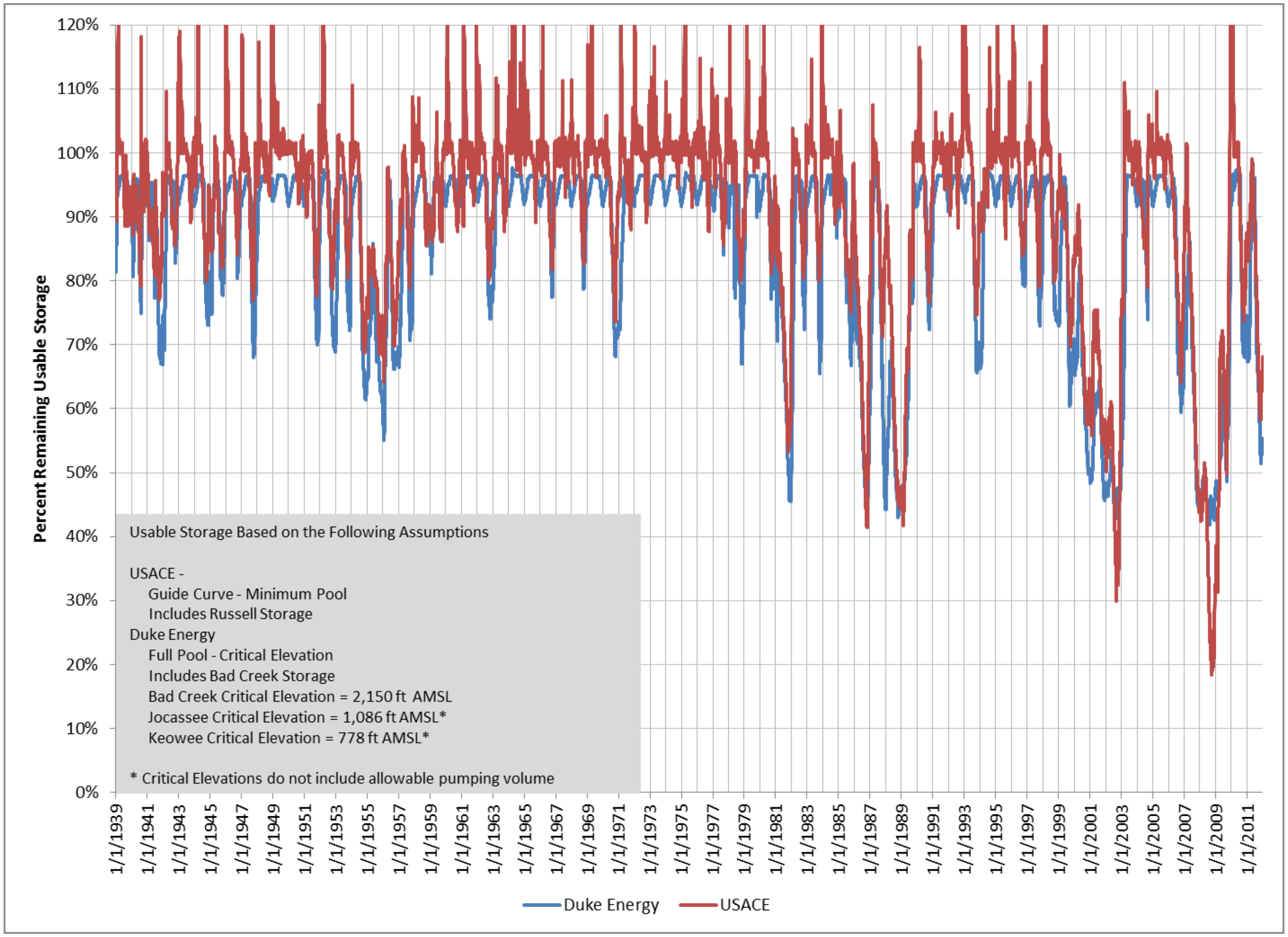


Figure 3.4-7 Duke Energy and USACE Reservoir Storage Percentages with Minimum JST Flow Release set at 3,800 cfs – A3 (Future Water Withdrawals with Historic Hydrology (1939–2011))

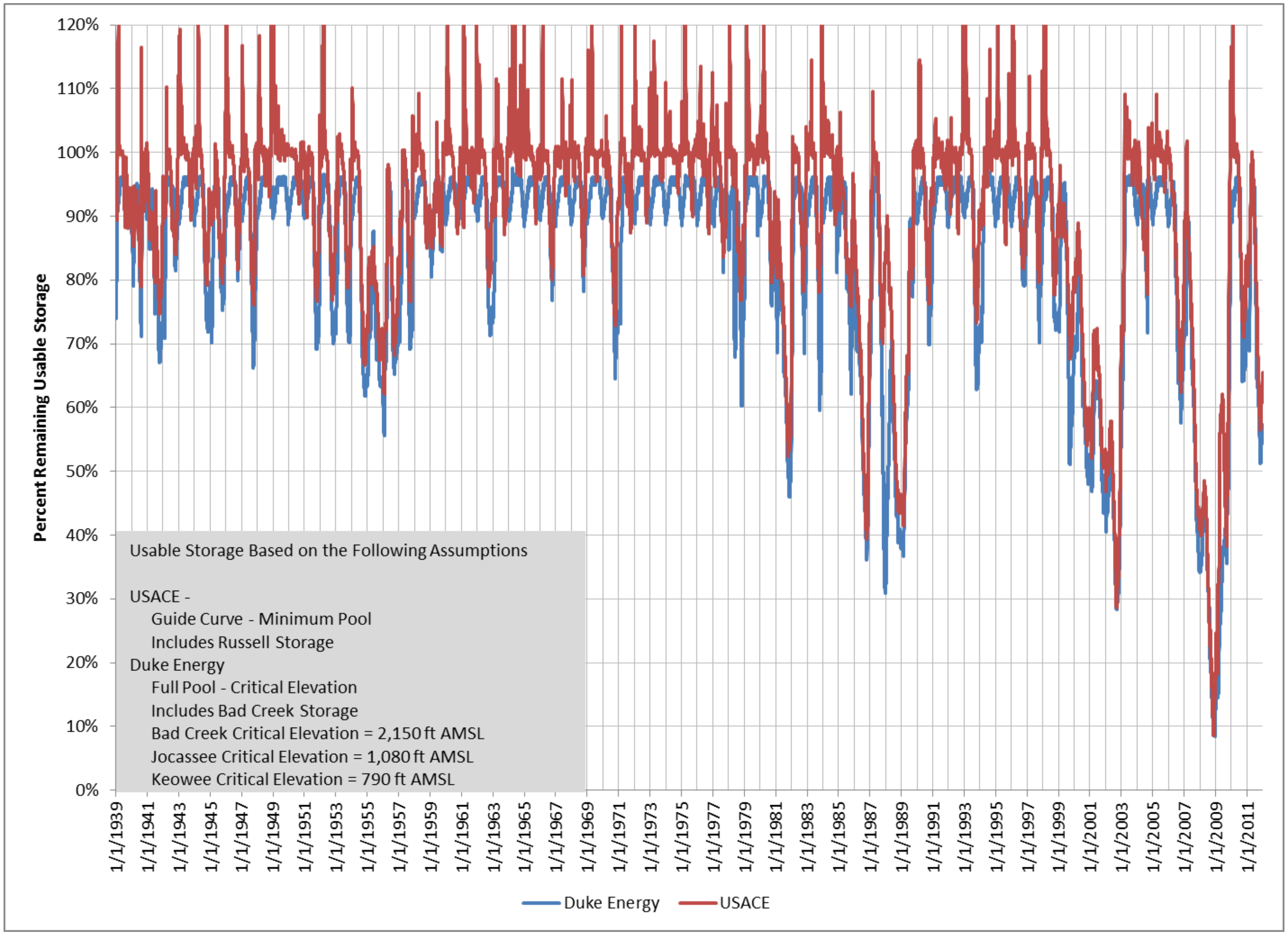


Figure 3.4-8 Duke Energy and USACE Reservoir Storage Percentages with Minimum JST Flow Release set at 3,800 cfs – A4 (Future Water Withdrawals with Historic Hydrology (1939–2011))

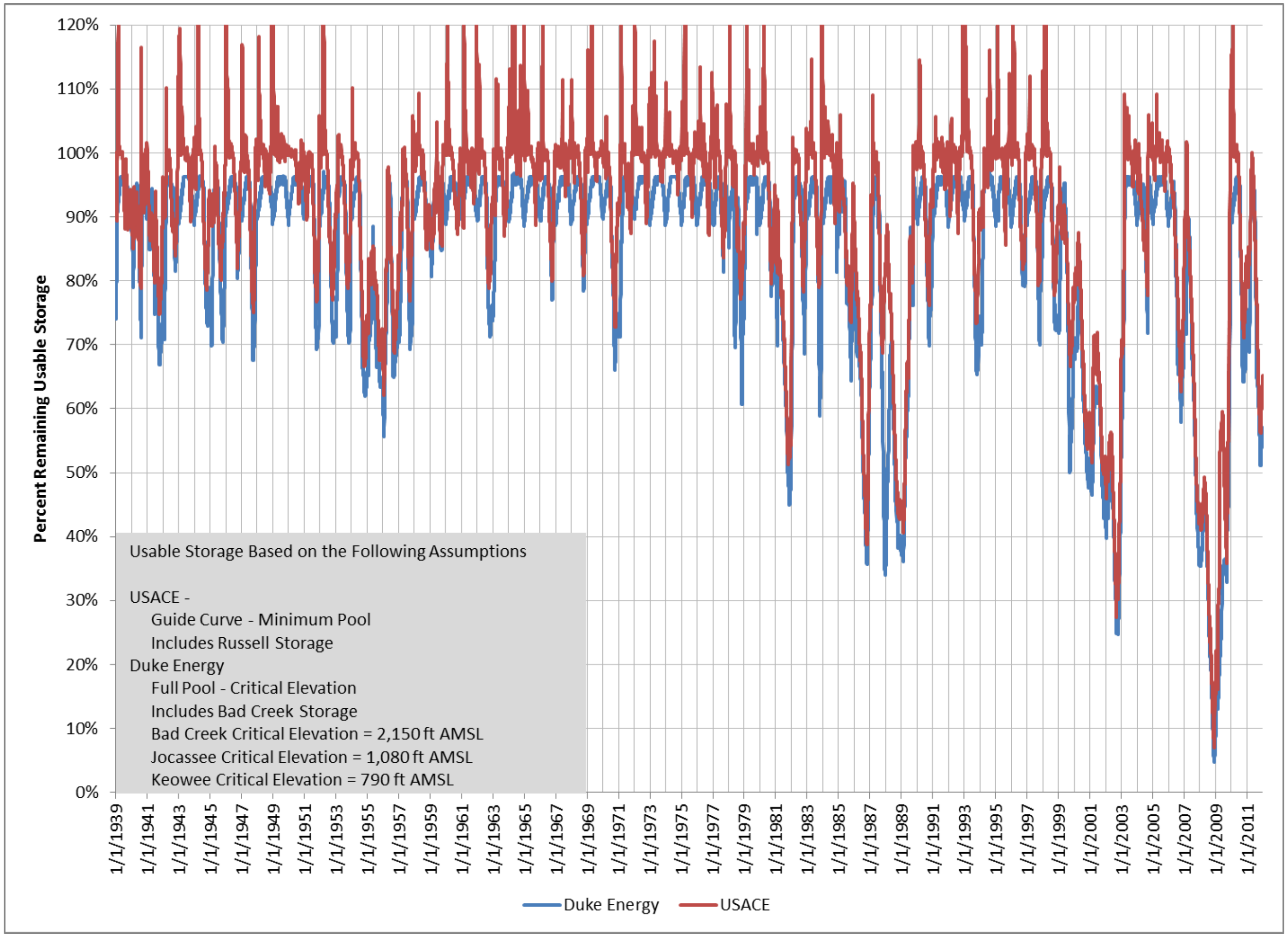
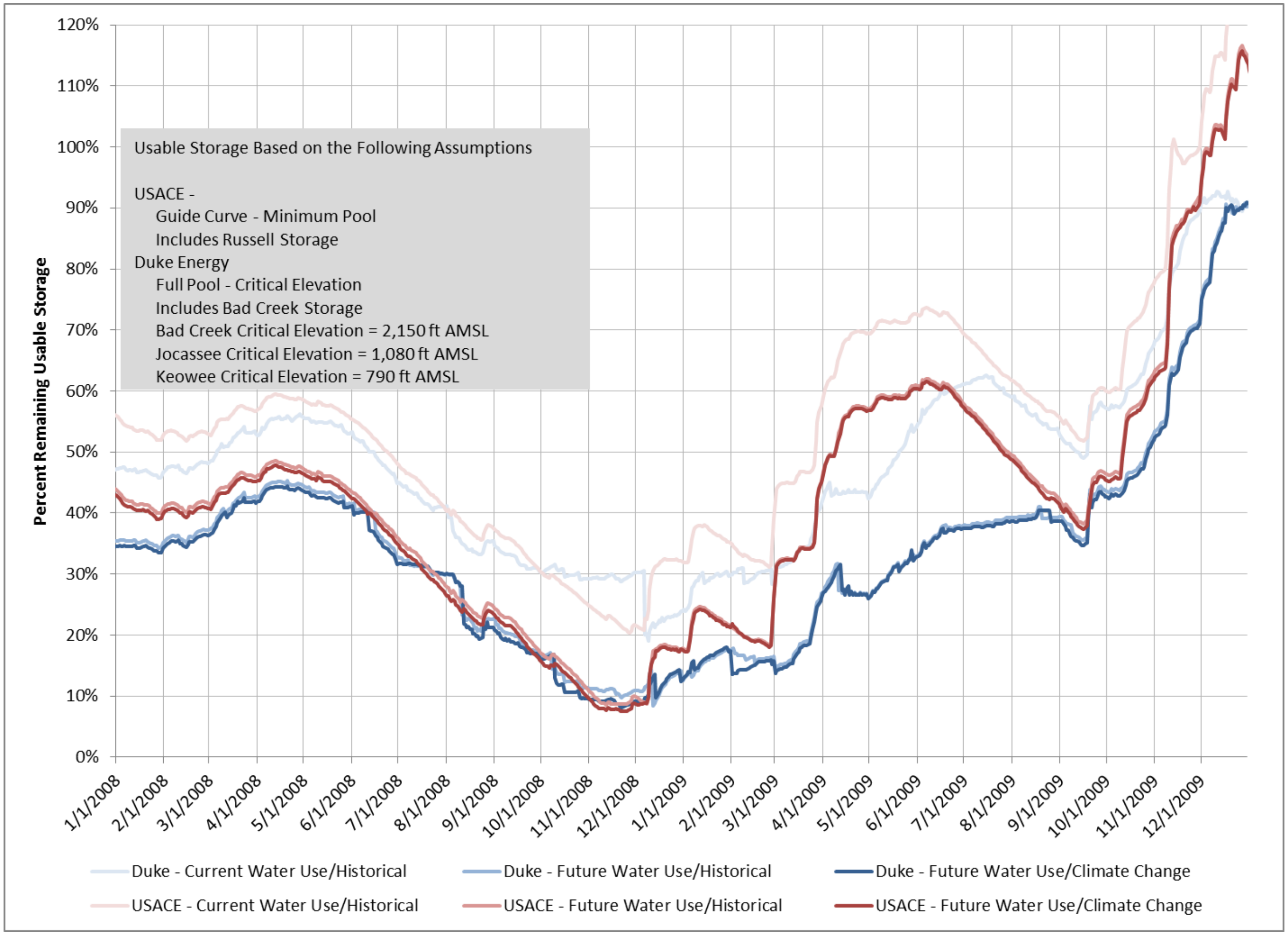


Figure 3.4-9 Duke Energy and USACE Reservoir Storage Percentages with Minimum JST Flow Release set at 3,800 cfs – A3 Summary (2008-2009)



3.5 Duke Energy Reservoir Elevation Results

HEC-ResSim model results for all four model scenarios for Duke Energy's Lakes Jocassee and Keowee are provided below. The results cover the 73-year POR for the future water withdrawal with historic hydrology conditions, as well as the sensitivity analyses described in Section 3.4.

3.5.1 *Future Water Withdrawals with Historic Hydrology*

Model results for Lakes Jocassee and Keowee assuming future water withdrawals with historic hydrology are provided in Figures 3.5-1 through 3.5-4. Figures 3.5-1 and 3.5-2 provide the 73-year POR results, while Figures 3.5-3 and 3.5-4 show a 6-year snapshot to aid in the results discussion.

Water stored in Lake Jocassee is used to help maintain required downstream flow releases to the USACE reservoirs, help maintain Lake Keowee levels at or above the required thresholds mandated by each scenario, and support operations at Bad Creek. As a result, Lake Jocassee experiences relatively large fluctuations in water surface elevation when compared to other reservoirs in the HEC-ResSim model (see Figure 3.5-1). Reservoir elevations in Lake Keowee are similarly affected as Jocassee Pumped Storage Station operations cycle water between Lakes Jocassee and Keowee, but to a lesser extent due to the required thresholds to maintain operations at the ONS (see Figure 3.5-2).

To get a sense of how the four model scenarios affect reservoir elevations in Lakes Jocassee and Keowee, the maximum difference between model scenarios was determined for each day in the 73-year POR. These maximum differences were then averaged over the 73-year POR. For Lake Jocassee the average difference in reservoir elevations between scenarios is 2.17 feet. For Lake Keowee, the average difference is 0.90 feet. This analysis indicates that while differences between model scenarios are relatively small over long periods, they are more pronounced for Lake Jocassee when compared to Lake Keowee.

When reviewing differences between model scenarios for both Lakes Jocassee and Keowee, A3 and A4 generally result in higher reservoir elevations. The additional storage capacity from the

Bad Creek Project along with a smaller usable storage capacity in Lake Keowee is the primary driver in keeping elevations higher in these two reservoirs. Minor differences between A3 and A4 are due to the LIP logic in A3.

For Lake Jocassee, there is little difference in reservoir elevation between the NAA/A1 and A2 model scenarios. In both cases, water stored in Lake Jocassee is used to maintain downstream flow releases below Lake Keowee (NAA/A1) and/or preserve Lake Keowee elevations to support ONS operations (A2). For NAA/A1, HEC-ResSim modeling for Lake Jocassee shows reservoir elevations near the minimum of 1,080 ft AMSL between August 2002 and August 2004 (see Figure 3.5-1). At the same time, Lake Keowee and all three USACE reservoirs are near full pool. This approximately two-year period of reservoir imbalance is an artifact of HEC-ResSim zone-boundary issues. In reality, Duke Energy would likely have more closely balanced usable storage in these two reservoirs. A3 and A4 produce different results from NAA/A1 and A2 because they assume a smaller usable volume for Lake Keowee and include storage from the Bad Creek Project. This assumption helps maintain Lake Keowee levels and thus, reduces the amount of water needed from Lake Jocassee. These incremental differences between scenarios for Lake Jocassee are shown in Figure 3.5-3.

While the 1968 Agreement uses elevation 1,086 feet AMSL as the lower reservoir limit for Lake Jocassee in the water storage balance calculations, the physical intake structure at Lake Jocassee allows reservoir operations down to 1,080 feet AMSL. The four alternatives result in reservoir drawdowns near this lower operational limit to help maintain water surface elevations as long as possible in Lake Keowee.

For Lake Keowee, there are minor differences between NAA/A1 and A2 as shown in Figure 3.5-4. NAA/A1 assumes Lake Keowee can be drawn down to elevation 778 feet AMSL and the modeling indicates that a maximum reservoir drawdown of 782 feet AMSL would be reached toward the end of the 2007–2008 drought period. A2 does not allow a non-emergency or non-ONS-related intentional flow release from Lake Keowee if that release would cause the reservoir elevation to drop below 794.6 feet AMSL. This assumption creates a 1-foot band of daily fluctuations in water surface elevations in Lake Keowee between 794 and 795 feet AMSL

(Figure 3.5-4). On those same days, a 2-foot band of daily fluctuating water surface elevations can be seen in the Lake Jocassee model results (Figure 3.5-3). These fluctuations are largely the result of HEC-ResSim model logic associated with pumped-storage operations at Jocassee Pumped Storage Station. When Lake Keowee is at or near 794.6 feet AMSL, model flow releases via the Keowee Hydro Station cease. However, daily operations continue at the Jocassee Pumped Storage Station. Daily generation and pump-back cycles modeled at the Jocassee Pumped Storage Station create these periods of fluctuating water surface elevations.

Figure 3.5-4 also indicates that while A3 and A4 generally result in higher reservoir elevations in Lake Keowee, a few exceptions would occur during extreme droughts. For example, toward the end of the 2007–2008 drought, A2 had higher reservoir elevations than A3 and A4. While A2 assumes the usable volume in Lake Keowee extends down to elevation 778 feet AMSL, a flow release is not made if it would cause the reservoir elevation to drop below 794.6 feet AMSL. This assumption results in higher Keowee reservoir elevations under A2 (compared to A3 and A4) for relatively short periods during extreme droughts. A3 and A4 result in similar reservoir elevations for both Lake Jocassee and Lake Keowee during extreme droughts.

None of the four reservoir operating scenarios result in Lake Jocassee elevations below its maximum drawdown of 1080 feet AMSL. For Lake Keowee, the NAA/A1 results in eight periods during the 73-year POR where the ONS would have been shut down due to Lake Keowee reservoir elevations below 793 feet AMSL (see Figure 3.5-2). The longest shutdown period was from June 20, 2008 to June 2, 2009, a span of 348 days. A2 results in relatively short periods below the current ONS operating threshold elevation of 794.6 feet AMSL, but would not result in an ONS shutdown. A3 and A4 do not result in Lake Keowee elevations below 790 feet AMSL.

Figure 3.5-1 Lake Jocassee Modeled Reservoir Elevations(Future Water Withdrawals with Historic Hydrology [1939–2011])

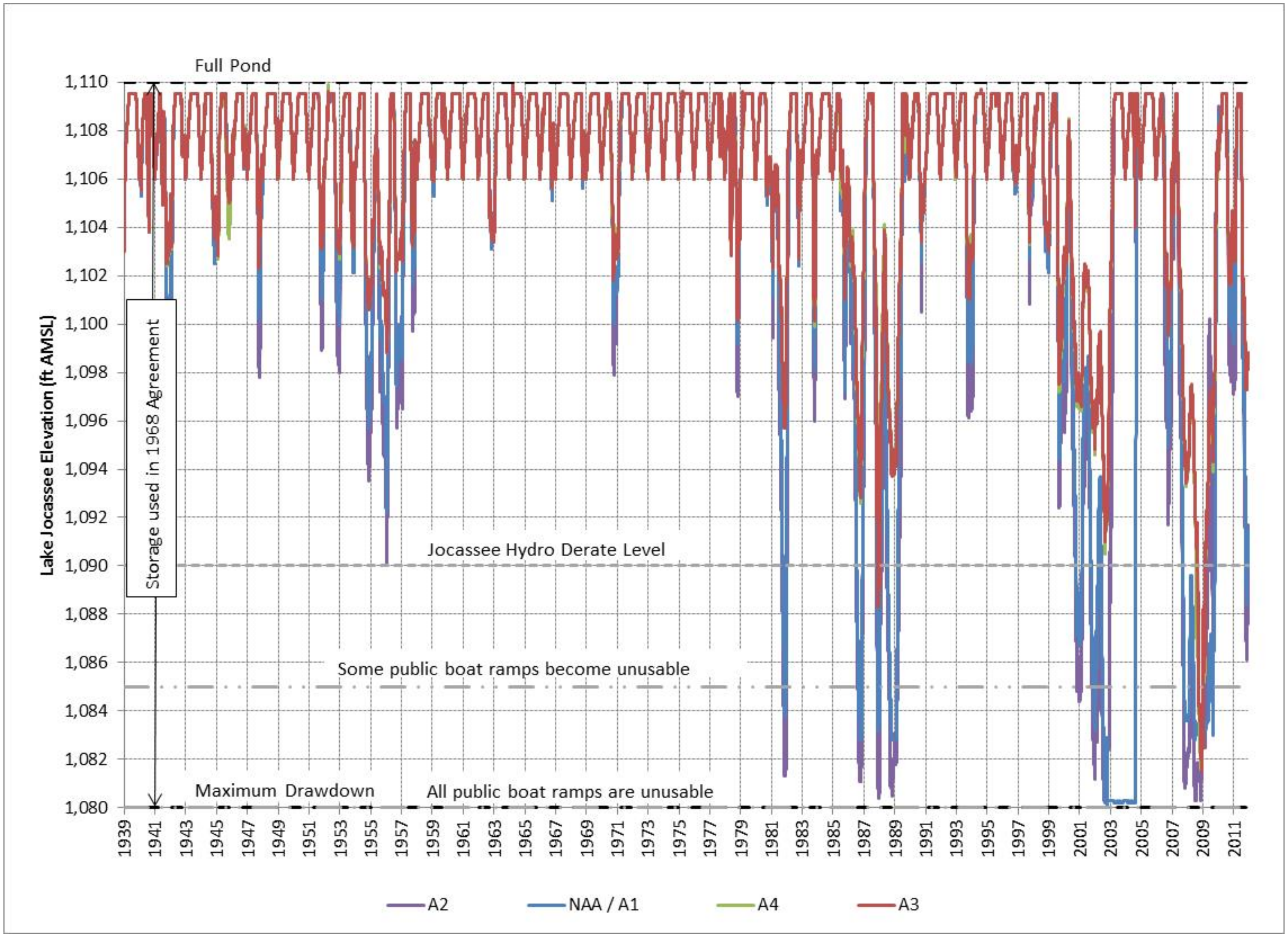


Figure 3.5-2 Lake Keowee Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [1939–2011])

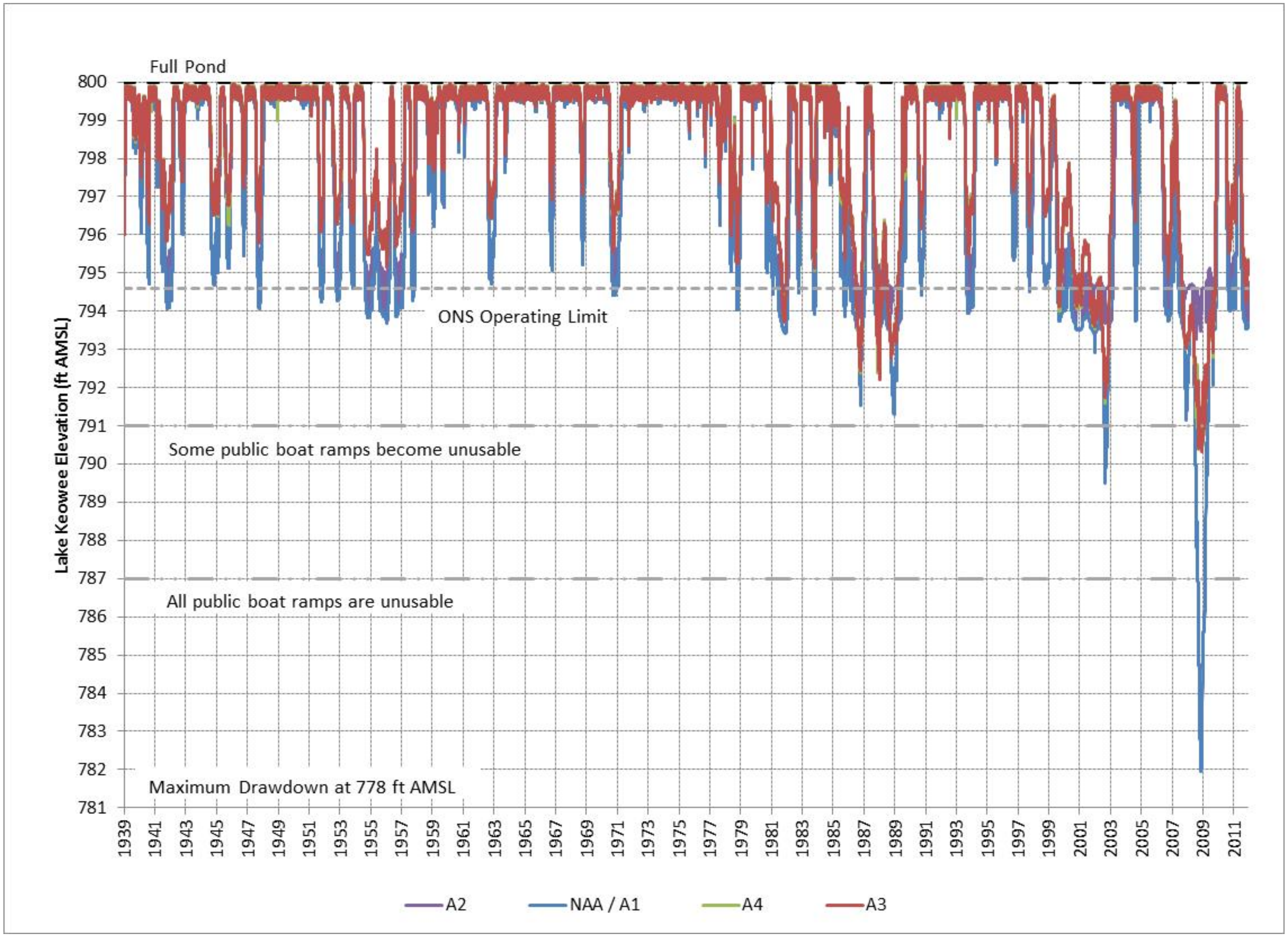


Figure 3.5-3 Lake Jocassee Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [2006–2011])

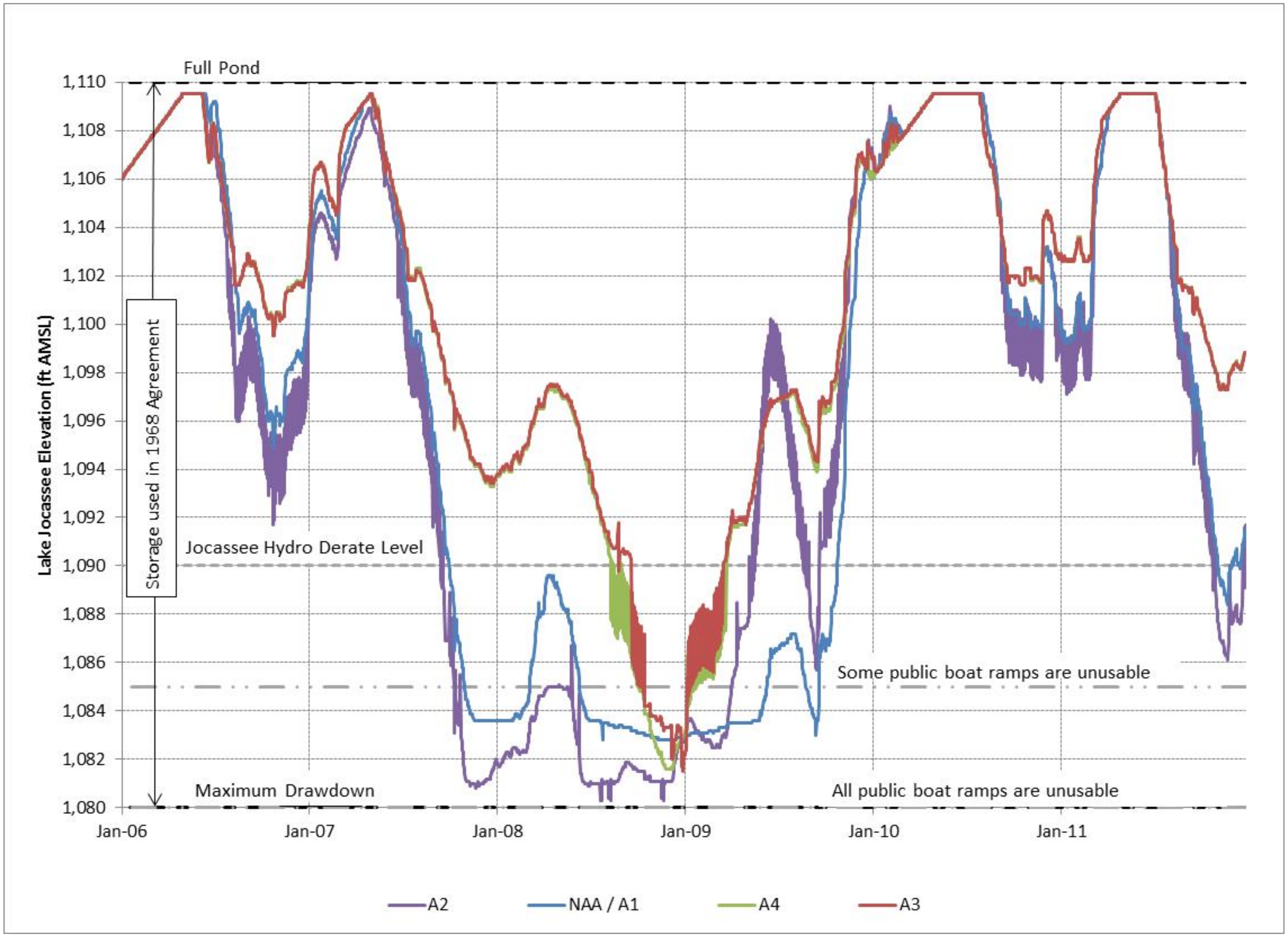
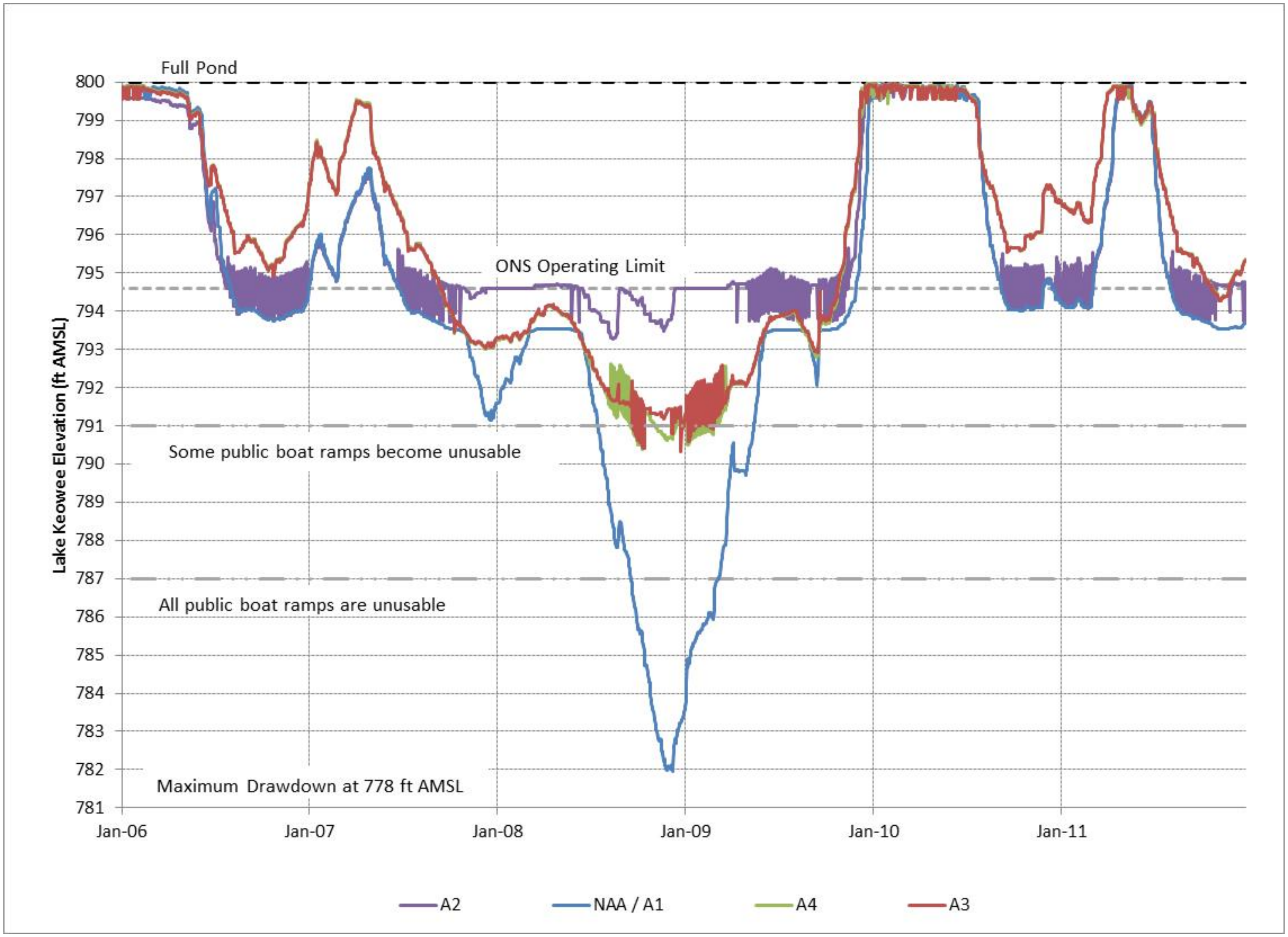


Figure 3.5-4 Lake Keowee Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [2006–2011])



3.5.2 *Hydrology and Water Withdrawal Sensitivity Analyses*

The results of the sensitivity analyses for Lakes Jocassee and Keowee are described below. Appendix M contains figures showing reservoir elevations over the 73-year POR for this sensitivity analysis.

3.5.2.1 *Current Water Withdrawals with Historic Hydrology*

Changing the water withdrawal assumption in the HEC-ResSim model from future levels to current levels does not alter the overall trends in the four operating scenarios over the 73-year POR, but the differences between scenarios are slightly smaller. This makes sense intuitively as less water is removed from the system for consumptive uses. For Lake Jocassee, the average difference between scenarios drops from 2.17 to 1.15 feet. As expected, this difference is larger during droughts. For example, during the 2007-2008 drought, the lowest reservoir elevation for A4 is 3 feet higher than it is under the future water withdrawal assumption. Similarly, for Lake Keowee, the average difference between scenarios drops from 0.90 to 0.73 feet.

3.5.2.2 *Future Water Withdrawals with Climate Change Hydrology*

Similarly, modifying the hydrology to simulate the potential effects of climate change conditions over the entire Savannah River Basin also does not alter the overall trends in the four operating scenarios over the 73-year POR, however, the differences between scenarios are slightly greater. Differences are not related to operations at the Keowee-Toxaway Project (i.e., they are related to climate change hydrologic conditions). This makes sense as accretion flows throughout the basin are reduced. For Lake Jocassee, the average difference between scenarios increases slightly from 2.17 to 2.23 feet. For Lake Keowee, the average difference between scenarios increases slightly from 0.90 to 0.95 feet.

3.6 USACE Reservoir Elevation Results

HEC-ResSim model results for all four model scenarios for USACE's Hartwell, RBR, and JST Reservoirs are provided below. The results cover the 73-year POR for the future water withdrawal and historic hydrology model assumptions as well as the sensitivity analyses described in Section 3.4.

3.6.1 *Future Water Withdrawals with Historic Hydrology*

Figures 3.6-1 through 3.6-6 show the model results for the Hartwell, RBR, and JST Reservoirs assuming future water withdrawals with historic hydrology. Figures 3.6-1 through 3.6-3 provide the 73-year POR results. Unlike Lakes Jocassee and Keowee, results for all four scenarios for the USACE reservoirs are almost identical over the entire modeled period. For example, over the 73-year POR, the average difference in reservoir elevation between scenarios for Hartwell Lake is 0.37 feet. For RBR, the average difference between scenarios is 0.35 feet and for JST the average difference is 0.30 feet. These differences are much smaller than those determined for Lakes Jocassee and Keowee (2.17 and 0.90 feet, respectively).

Figures 3.6-4 through 3.6-6 provide a 6-year snapshot for each of the USACE's reservoirs illustrating differences in pool elevations that are relatively infrequent and small in magnitude. During less severe droughts, such as occurred at the end of 2006, A3 and A4 result in slightly lower reservoir elevations for Hartwell and JST Lakes (by approximately 0.7 and 0.5 feet, respectively) compared to NAA/A1.

Overall, the four operating scenarios produce very similar results for the USACE's reservoirs. Differences are relatively small, occur infrequently, and are temporary.

Figure 3.6-1 Hartwell Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [1939–2011])

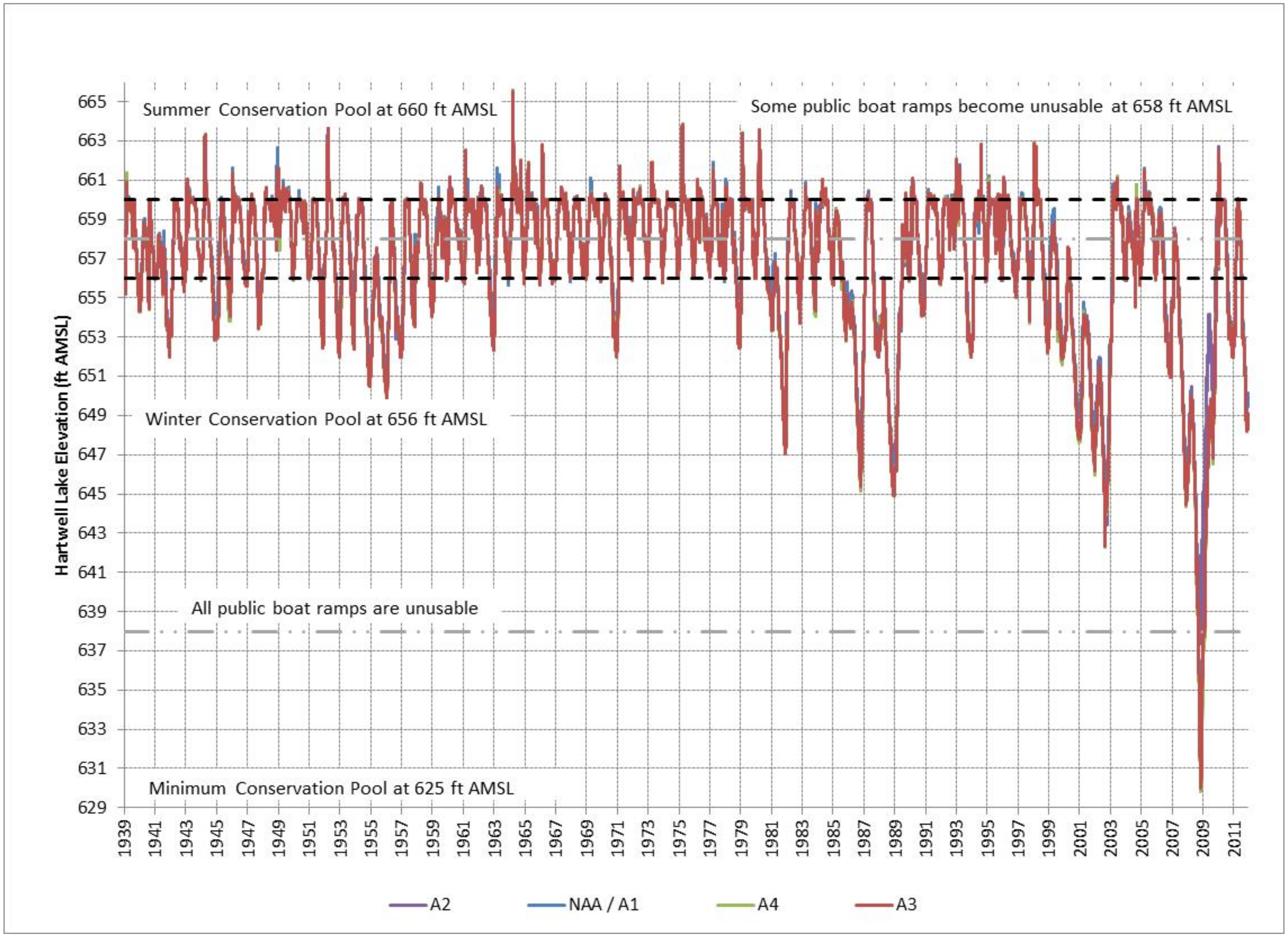


Figure 3.6-2 RBR Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [1939–2011])

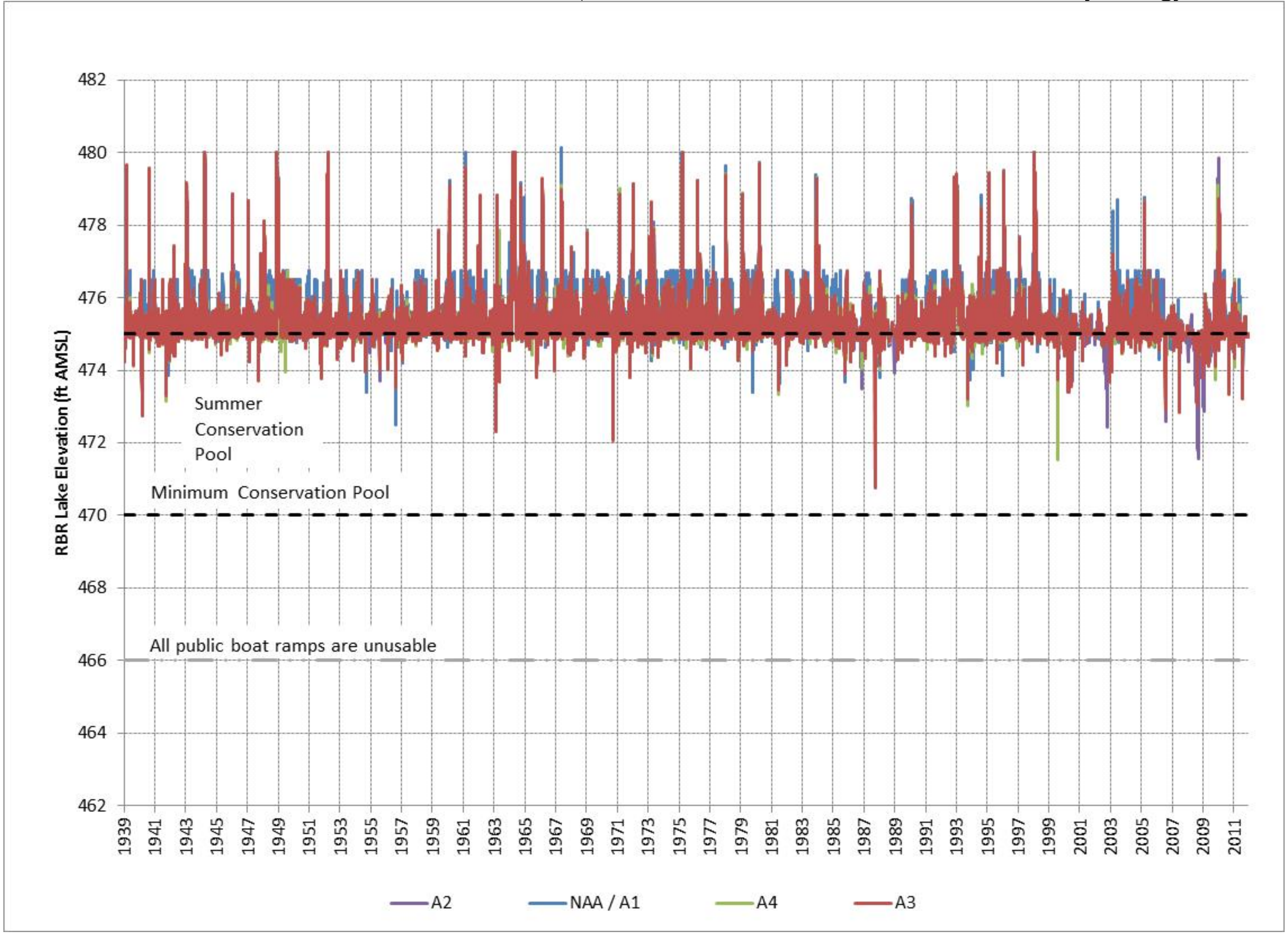


Figure 3.6-3 JST Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [1939–2011])

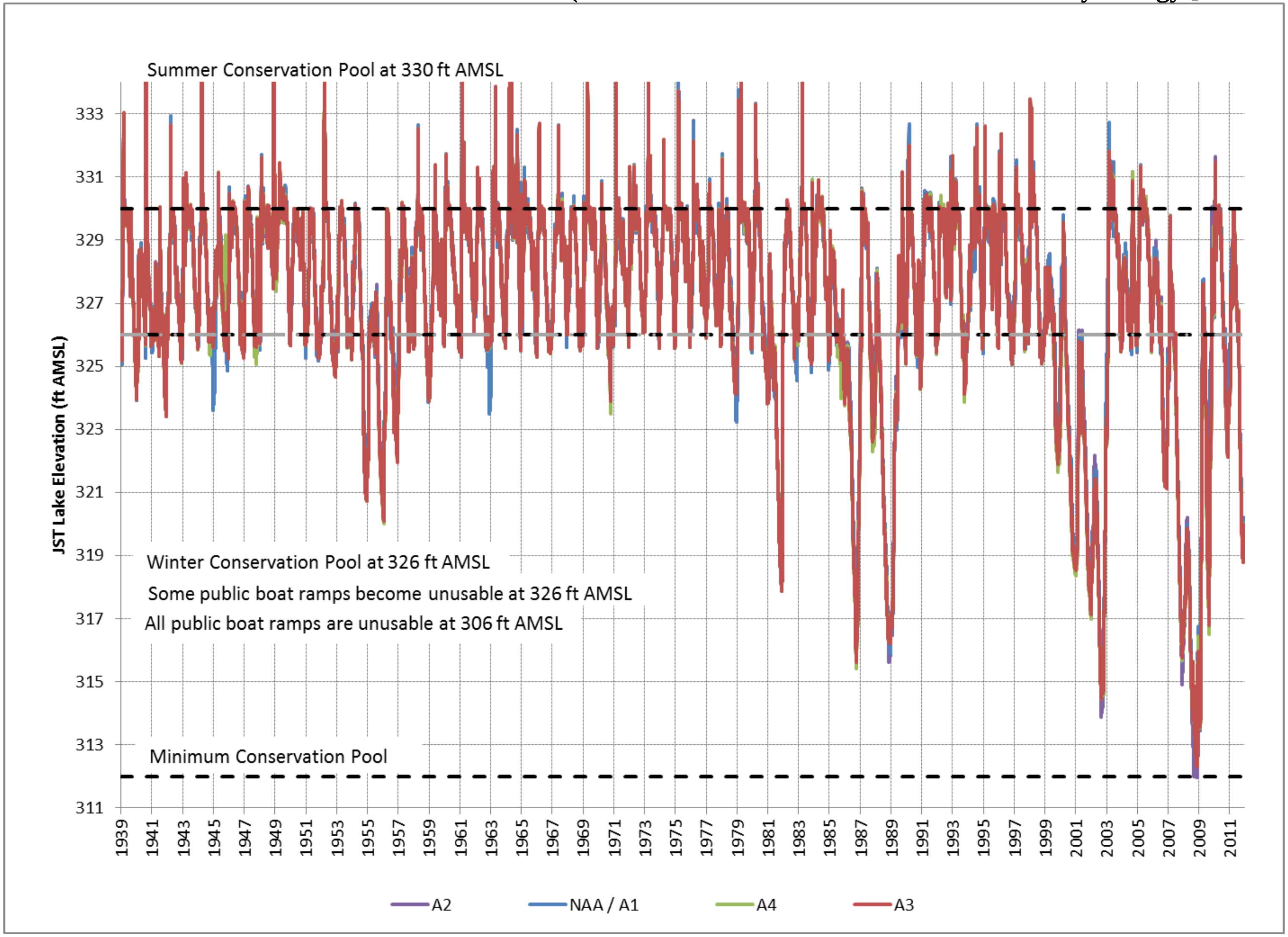


Figure 3.6-4 Hartwell Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [2006–2011])

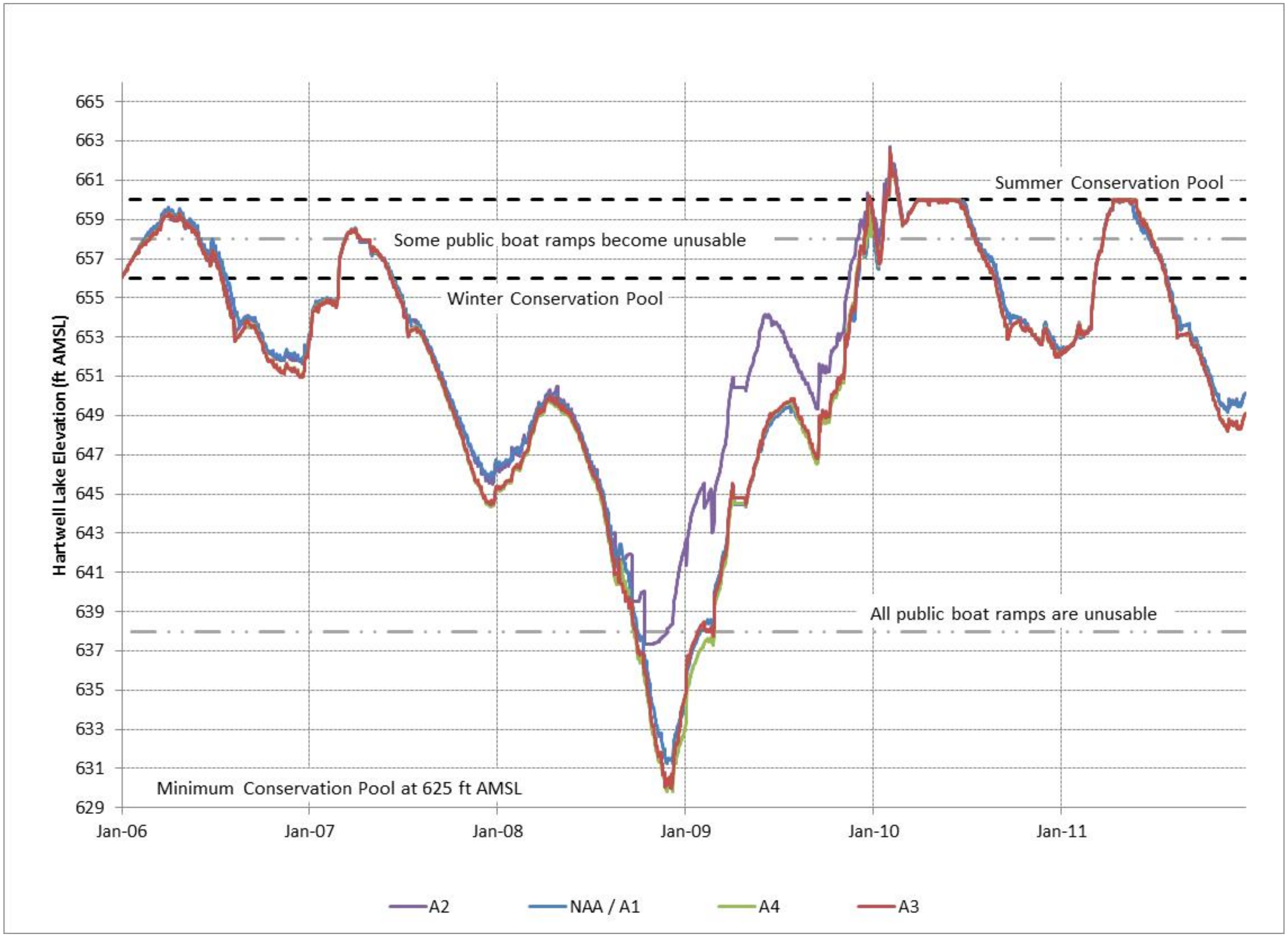
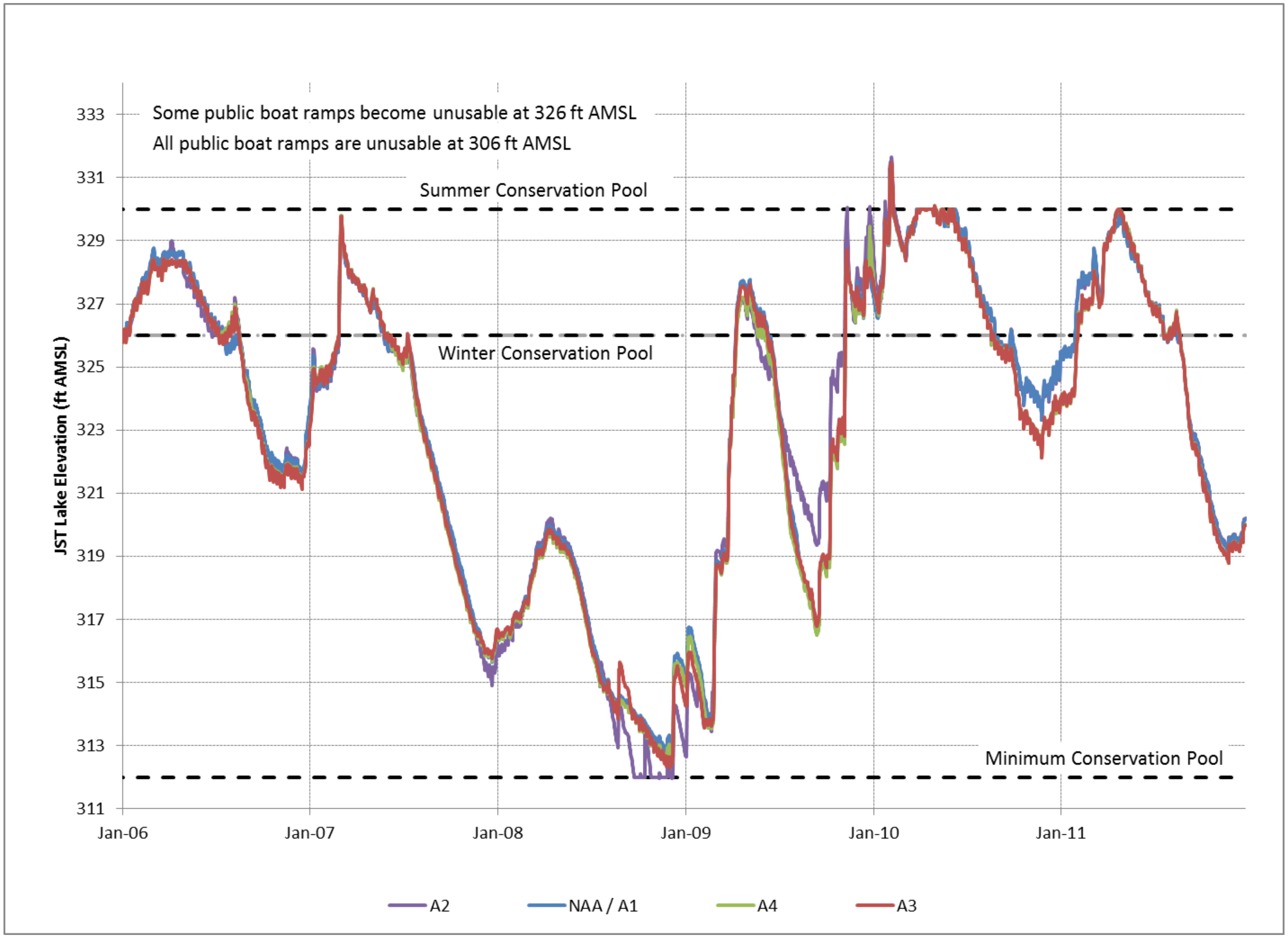


Figure 3.6-5 RBR Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [2006–2011])

Figure 3.6-6 JST Lake Modeled Reservoir Elevations (Future Water Withdrawals with Historic Hydrology [2006–2011])



3.6.2 *Hydrology and Water Withdrawal Sensitivity Analyses*

The results of the sensitivity analyses for reservoir levels are described below and summarized in Table 3.7-3. Appendix M contains figures showing reservoir elevations over the 73-year POR for the sensitivity analyses.

3.6.2.1 *Current Water Withdrawals with Historic Hydrology*

Similar to the Duke Energy reservoirs, limiting net water withdrawals to current levels resulted in smaller differences between the four scenarios for the USACE reservoirs. For Hartwell, the average difference between scenarios dropped from 0.37 to 0.22 feet. For RBR, the average difference between scenarios dropped from 0.35 to 0.34 feet, and for JST the difference dropped from 0.30 to 0.22 feet.

3.6.2.2 *Future Water Withdrawals with Climate Change Hydrology*

Similar to the effects observed in modeling of the Duke Energy reservoirs, reducing inflows to simulate basin-wide potential climate changes did not alter the overall reservoir elevation trends for the USACE reservoirs. However, the differences between scenarios are generally slightly larger when potential climate changes are included. For Hartwell, the average difference between scenarios increased from 0.37 to 0.40 feet. For RBR, the average difference increased from 0.35 to 0.36 feet, and for JST, there was no change in the average difference between scenarios (0.30 feet).

3.7 JST Lake Flow Release Results

3.7.1 *Future Water Withdrawals with Historic Hydrology*

Reservoir elevations at Hartwell and JST Reservoirs have a direct influence on flow releases to the Savannah River downstream of JST. As described in Section 3.5, all four alternatives result in similar reservoir elevations over the 73-year POR for the USACE reservoirs. As a result, flow releases to the Savannah River downstream of JST are also similar between the four modeled scenarios.

To evaluate potential flow-related environmental impacts downstream from the JST Project, an analysis of average flows on a yearly basis was conducted. Only those years that triggered the

USACE's 2012 DP were used in the analysis because the Operating Agreement goes into effect when the system is experiencing a drought. The higher flow months of January through March were excluded from the analysis to better focus the analysis on lower flow release periods.

Based on HEC-ResSim model results, 51 of the 73 years in the POR trigger the USACE 2012 DP. Average JST flow releases (April through December) for each of those 51 years is provided in Table 3.7-1 for each alternative. The average flows from April through December for A2, A3, and A4 were compared to the NAA/A1 model scenario for each drought year. These differences are expressed as a percentage compared to the NAA/A1 on the right half of Table 3.7-1. A positive percentage indicates a given alternative's average flow is higher than the NAA/A1 average flow while a negative percentage indicates a given alternative's average flow is less than the NAA/A1 average flow.

Table 3.7-1 Annual Average JST Flow Releases April – December for Drought Years (Future Water Withdrawals with Historic Hydrology)

Year	Average Flow (cfs)				Percent Difference Compared to NAA/A1		
	NAA/A1	A2	A3	A4	A2	A3	A4
1940	6,976	6,976	6,920	6,914	0.0%	-0.8%	-0.9%
1941	5,626	5,625	5,539	5,538	0.0%	-1.6%	-1.6%
1942	5,991	5,992	6,029	6,022	0.0%	0.6%	0.5%
1944	7,894	7,894	7,746	7,755	0.0%	-1.9%	-1.8%
1945	6,240	6,240	6,244	6,223	0.0%	0.1%	-0.3%
1946	7,130	7,130	7,151	7,134	0.0%	0.3%	0.1%
1947	7,566	7,565	7,503	7,499	0.0%	-0.8%	-0.9%
1951	5,971	5,971	5,933	5,931	0.0%	-0.6%	-0.7%
1952	6,856	6,856	6,824	6,848	0.0%	-0.5%	-0.1%
1953	6,375	6,375	6,404	6,398	0.0%	0.5%	0.4%
1954	5,057	5,057	5,074	5,065	0.0%	0.3%	0.2%
1955	4,135	4,136	4,112	4,118	0.0%	-0.6%	-0.4%
1956	4,422	4,422	4,448	4,419	0.0%	0.6%	-0.1%
1957	6,525	6,522	6,764	6,719	0.0%	3.5%	2.9%
1958	6,340	6,340	6,388	6,387	0.0%	0.8%	0.7%
1959	6,781	6,781	6,764	6,765	0.0%	-0.2%	-0.2%
1962	6,701	6,701	6,531	6,527	0.0%	-2.6%	-2.7%
1963	7,630	7,630	7,632	7,631	0.0%	0.0%	0.0%
1966	6,220	6,220	6,248	6,220	0.0%	0.4%	0.0%

Year	Average Flow (cfs)				Percent Difference Compared to NAA/A1		
	NAA/A1	A2	A3	A4	A2	A3	A4
1968	6,506	6,506	6,512	6,512	0.0%	0.1%	0.1%
1970	5,260	5,258	5,264	5,258	0.0%	0.1%	0.0%
1971	7,106	7,107	7,245	7,237	0.0%	1.9%	1.8%
1978	5,633	5,632	5,598	5,583	0.0%	-0.6%	-0.9%
1979	9,638	9,638	9,712	9,713	0.0%	0.8%	0.8%
1980	8,172	8,172	8,187	8,188	0.0%	0.2%	0.2%
1981	4,027	4,026	4,088	4,081	0.0%	1.5%	1.3%
1982	6,296	6,266	6,323	6,322	-0.5%	0.4%	0.4%
1983	8,925	8,925	8,923	8,901	0.0%	0.0%	-0.3%
1985	5,093	5,055	5,072	5,084	-0.8%	-0.4%	-0.2%
1986	3,927	3,937	3,854	3,883	0.3%	-1.9%	-1.1%
1987	5,017	5,069	5,038	5,073	1.0%	0.4%	1.1%
1988	3,964	3,924	3,889	3,893	-1.0%	-1.9%	-1.8%
1989	6,392	6,459	6,587	6,595	1.0%	2.9%	3.1%
1990	5,700	5,700	5,727	5,741	0.0%	0.5%	0.7%
1993	6,734	6,735	6,562	6,555	0.0%	-2.6%	-2.7%
1994	9,341	9,368	9,469	9,457	0.3%	1.3%	1.2%
1996	6,859	6,859	6,928	6,879	0.0%	1.0%	0.3%
1997	7,110	7,126	7,093	7,094	0.2%	-0.2%	-0.2%
1998	8,266	8,266	8,250	8,250	0.0%	-0.2%	-0.2%
1999	4,454	4,454	4,379	4,432	0.0%	-1.7%	-0.5%
2000	4,225	4,223	4,182	4,143	-0.1%	-1.0%	-2.0%
2001	3,919	3,918	3,937	3,921	0.0%	0.5%	0.0%
2002	3,791	3,819	3,771	3,769	0.7%	-0.5%	-0.6%
2003	9,402	9,286	9,435	9,434	-1.2%	0.3%	0.3%
2004	7,085	7,453	7,394	7,394	4.9%	4.2%	4.2%
2006	4,226	4,242	4,160	4,146	0.4%	-1.6%	-1.9%
2007	4,024	4,011	4,015	4,027	-0.3%	-0.2%	0.1%
2008	3,717	3,177	3,711	3,711	-17.0%	-0.2%	-0.2%
2009	5,335	5,603	5,347	5,314	4.8%	0.2%	-0.4%
2010	4,970	4,970	5,015	5,013	0.0%	0.9%	0.9%
2011	4,246	4,245	4,283	4,271	0.0%	0.9%	0.6%
Drought Year Average					**-0.1%**	**0.0%**	**0.0%**
Drought Year Minimum					**-17.0%**	**-2.6%**	**-2.7%**
Drought Year Maximum					**4.9%**	**4.2%**	**4.2%**

Key observations related to the JST flow releases shown in Table 3.7-1 are:

- The USACE 2012 DP is triggered 51 years out of the 73-year POR based on HEC-ResSim model results for A3 and A4.
- JST flow releases for A3 and A4 are more similar to NAA/A1 flow releases than they are to A2.
- Over the 51 drought years in the 73-year POR, A3 average flow releases are:
  - Less than NAA/A1 average flow releases for 22 years
  - Equal to or greater than NAA/A1 average flow releases for 29 years
- The differences between A3/A4 and NAA/A1 are less than 5 percent on an annual basis. The larger negative differences (i.e., 1962 and 1993) and larger positive differences (i.e., 1957, 1989, and 2004) tend to occur during less severe drought years when average flows are above 4,200 cfs.
- For A3 and A4, there are no consecutive extreme drought years where the average flow releases are less than the NAA/A1 average flow releases by more than 2 percent. For example, A3 average flows were 1.9 percent less than NAA/A1 average flow releases in 1988 followed by a 2.9 percent increase in 1989. During the 2007 – 2009 extreme drought, A3 average flows are less than NAA/A1 average flow releases by -0.2 percent, -0.2 percent, and +0.2 percent for 2007, 2008, and 2009, respectively.

As discussed in Section 3.3.3, state and/or federal regulatory agencies in Georgia and/or South Carolina may request implementation of adaptive management flow releases at the JST Project when JST flow releases fall below 3,800 cfs (i.e., during DP Levels 2, 3, and 4) to support downstream water quality. As a result, the small differences in April through December average JST flow releases presented in Table 3.7-1 would be even smaller if the adaptive management flow releases are implemented. As described in Section 3.4 (and shown in Figures 3.4-5 through 3.4-8), the Duke Energy system can support the adaptive management flows. This is still the case even under the worst case sensitivity analysis, which assumes future water withdrawals with climate change hydrology and adaptive management flow releases in every Level 2 and 3 day (note Level 4 conditions are never reached even in this worst-case scenario).

Average monthly flows (April through December) during drought years for each alternative are provided in Table 3.7-2.

Table 3.7-2 Monthly Average Flow Releases April 1 – December 31 for Drought Years (Future Water Withdrawals with Historic Hydrology)

Month	Average Flow (cfs)				Percent Difference Compared with NAA/A1		
	NAA/A1	A2	A3	A4	A2	A3	A4
April	9,041	9,055	9,082	9,083	0.2%	0.5%	0.5%
May	6,492	6,490	6,567	6,541	0.0%	1.1%	0.8%
June	5,276	5,279	5,258	5,269	0.1%	-0.3%	-0.1%
July	5,827	5,814	5,881	5,916	-0.2%	0.9%	1.5%
August	5,785	5,779	5,841	5,857	-0.1%	1.0%	1.2%
September	5,086	5,103	5,026	4,946	0.3%	-1.2%	-2.8%
October	4,794	4,806	4,740	4,741	0.2%	-1.1%	-1.1%
November	5,467	5,464	5,409	5,417	-0.1%	-1.1%	-0.9%
December	6,920	6,908	6,953	6,947	-0.2%	0.5%	0.4%
Drought Year Average					**0.0%**	**0.0%**	**-0.1%**
Drought Year Minimum					**-0.2%**	**-1.2%**	**-2.8%**
Drought Year Maximum					**0.3%**	**1.1%**	**1.5%**

Key observations from the JST monthly flow release data in Table 3.7-2 are:

- For A3, monthly average differences in JST flow releases (i.e., +1.1 percent to -1.2 percent) compared to NAA/A1 are smaller than the range of annual differences shown in Table 3.7-1 for A3 (i.e., +4.2 percent to -2.6 percent).
- Even during September when A3 has the largest negative difference (-1.2 percent) compared to NAA/A1, the A3 monthly average flows are still well above (e.g., 5,026 cfs) USACE 2012 DP flow release minimums (3,800 cfs to 4,200 cfs depending on drought level).

The number of days the USACE system is within each Drought Plan Level for each alternative is shown in the table on the following page.

Table 3.7-3 Days Within Drought Levels

Year	Drought Level 1				Drought Level 2				Drought Level 3				Total			
	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	16	16	21	25	0	0	0	0	0	0	0	0	16	16	21	25
1941	130	130	60	60	0	0	91	92	0	0	0	0	130	130	151	152
1942	48	48	1	1	0	0	48	48	0	0	0	0	48	48	49	49
1943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	72	72	105	102	0	0	0	0	0	0	0	0	72	72	105	102
1945	40	40	124	150	0	0	0	0	0	0	0	0	40	40	124	150
1946	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
1947	36	36	29	31	40	40	57	55	0	0	0	0	76	76	86	86
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	89	89	102	102	0	0	0	0	0	0	0	0	89	89	102	102
1952	95	95	97	96	0	0	6	6	0	0	0	0	95	95	103	102
1953	89	89	89	89	0	0	30	40	0	0	0	0	89	89	119	129
1954	32	32	25	24	98	98	112	112	0	0	0	0	130	130	137	136
1955	69	67	47	50	235	235	248	249	0	0	0	0	304	302	295	299
1956	55	55	33	33	210	210	217	219	0	0	0	0	265	265	250	252
1957	79	79	84	84	63	63	59	59	0	0	0	0	142	142	143	143
1958	3	3	1	1	0	0	0	0	0	0	0	0	3	3	1	1
1959	18	18	19	19	0	0	0	0	0	0	0	0	18	18	19	19
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	80	80	113	113	0	0	0	0	0	0	0	0	80	80	113	113
1963	10	10	22	22	0	0	0	0	0	0	0	0	10	10	22	22
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	3	3	17	16	0	0	0	0	0	0	0	0	3	3	17	16
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	1	1	5	5	0	0	0	0	0	0	0	0	1	1	5	5
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	115	115	35	32	0	0	87	93	0	0	0	0	115	115	122	125
1971	25	25	1	1	0	0	33	35	0	0	0	0	25	25	34	36
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	78	78	99	97	0	0	0	0	0	0	0	0	78	78	99	97
1979	19	19	19	19	0	0	0	0	0	0	0	0	19	19	19	19
1980	5	5	30	29	0	0	0	0	0	0	0	0	5	5	30	29
1981	124	123	152	151	174	175	177	177	0	0	0	0	298	298	329	328
1982	24	24	67	67	33	32	33	33	0	0	0	0	57	56	100	100
1983	23	23	61	69	0	0	0	0	0	0	0	0	23	23	61	69
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	57	56	46	57	53	53	55	64	0	0	0	0	110	109	101	121
1986	104	110	115	60	245	236	189	242	0	0	56	58	349	346	360	360
1987	28	27	31	27	118	118	125	126	0	0	0	0	146	145	156	153
1988	0	0	0	0	352	322	312	313	14	44	54	53	366	366	366	366
1989	3	1	1	1	125	125	121	122	61	59	63	63	189	185	185	186
1990	33	33	91	91	0	0	0	0	0	0	0	0	33	33	91	91
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	27	27	28	29	84	84	92	91	0	0	0	0	111	111	120	120
1994	1	1	1	1	60	60	60	60	0	0	0	0	61	61	61	61
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
1997	29	29	40	42	0	0	0	0	0	0	0	0	29	29	40	42
1998	101	101	110	110	0	0	0	0	0	0	0	0	101	101	110	110
1999	56	56	54	58	119	119	130	127	0	0	0	0	175	175	184	185
2000	46	47	45	50	266	265	270	269	0	0	0	0	312	312	315	319
2001	0	0	0	0	365	365	365	365	0	0	0	0	365	365	365	365
2002	0	0	0	0	256	249	240	217	109	116	125	148	365	365	365	365
2003	1	1	1	1	57	64	64	64	0	0	0	0	58	65	65	65
2004	15	15	21	21	0	0	0	0	0	0	0	0	15	15	21	21
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	26	26	30	30	137	144	145	145	0	0	0	0	163	170	175	175
2007	76	80	72	69	157	151	139	136	23	30	42	45	256	261	253	250
2008	0	0	0	0	130	125	118	118	236	241	248	248	366	366	366	366
2009	1	1	4	1	180	232	175	173	155	84	154	155	336	317	333	329
2010	26	26	23	26	98	98	105	105	0	0	0	0	124	124	128	131
2011	25	25	24	24	203	203	203	203	0	0	0	0	228	228	227	227
Total	**2033**	**2037**	**2198**	**2189**	**3858**	**3866**	**4106**	**4158**	**598**	**574**	**742**	**770**	**6489**	**6477**	**7046**	**7117**

Key observations from data shown in Table 3.7-3 for the number of days the USACE reservoirs are in drought with the various alternatives are:

- A2 would decrease the number of days the USACE reservoirs are in a drought (12 days out of 6489) (0.2% decrease), when compared to the NAA/A1.
- A3 would increase the number of days the USACE reservoirs are in a drought (6489 plus 557 days) (8.6% increase), when compared to the NAA/A1.
- A4 would increase the number of days the USACE reservoirs are in a drought (6489 plus 628 days) (9.7% increase), when compared to the NAA/A1.
- All alternatives would increase the number of days the USACE reservoirs are in a drought Levels 1 and 2, when compared to the NAA/A1.
- A2 and A3 would increase the number of days the USACE reservoirs are in a drought Level 3, when compared to the NAA/A1.
- Since the USACE Drought Plan calls for reductions in flow releases from JST when the USACE system is in a drought status, downstream flow releases would be reduced more days with alternatives A2 and A3.

3.7.2 ***JST Lake Flow Release Sensitivity Analyses***

The results of JST flow releases with the sensitivity analyses are provided in Table 3.7-3. Appendix M contains detailed April through December average flow releases for drought years (similar to Tables 3.7-1 and 3.7-4) for the sensitivity analyses.

Compared to future withdrawals with historic hydrology, current withdrawals result in smaller differences in JST releases for A2 (compared to NAA/A1). JST flow releases for A3 and A4 using current withdrawals are slightly lower on average (-0.2 percent) than NAA/A1 JST flow releases using future withdrawal assumptions (0.0 percent). The differences in monthly average JST flow releases are similar between current and future withdrawal assumptions for each alternative (compared to NAA/A1). Comparing current to future water withdrawal assumptions, A3 has same number of years (i.e., 22 years) where average JST flow releases are less than NAA/A1.

Compared to future withdrawals with historic hydrology, climate change hydrology results in similar differences in JST flow releases for A2, A3, and A4 (compared to NAA/A1). The differences in monthly average JST flow releases are similar between historic and climate change hydrology for each alternative (compared to NAA/A1). Using climate change hydrology assumptions, A3 results in four more years where average flows are less than NAA/A1 (26 years versus 22 years under historic hydrology).

Appendix M contains information showing the number of days the USACE reservoirs are in drought with the various alternatives under the sensitivity analyses. In general, that information indicates the following:

- The USACE reservoirs would be in drought fewer days under the scenario of Current Water Withdrawals and Historic Hydrology.
- The USACE reservoirs would be in drought more days under the scenario of Future Water Withdrawals and Climate Change Hydrology.

Table 3.7-4 Summary of JST Flow Release Statistics

	Base Plan	Sensitivity Analysis #1	Sensitivity Analysis #2
	Future Withdrawals with Historic Hydrology	Current Withdrawals with Historic Hydrology	Future Withdrawals with Climate Change Hydrology
Years DP Triggered over 73-year POR	51	44	52
Annual average difference[1] in JST flow releases compared to NAA/A1	A2: -0.1% A3: 0.0% A4: 0.0%	A2: 0.0% A3: -0.2% A4: -0.2%	A2: -0.3% A3: 0.0% A4: 0.0%
Range of annual differences[1] in JST flow releases compared to NAA/A1	A2: +4.9% to -17.0% A3: +4.2% to -2.6% A4: +4.2% to -2.7%	A2: +0.8% to -0.9% A3: +2.5% to -2.8% A4: +2.4% to -2.8%	A2: +4.9% to -22.0% A3: +4.3% to -2.2% A4: +4.3% to -2.5%
Range of monthly differences[1] in JST flow releases compared to NAA/A1	A2: +0.3% to -0.2% A3: +1.1% to -1.2% A4: +1.5% to -2.8%	A2: +0.1% to -0.3% A3: +1.7% to -2.0% A4: +1.8% to -2.0%	A2: +0.5% to -0.9% A3: +1.3% to -1.9% A4: +1.4% to -1.7%
Comparison of A3 to NAA/A1 average flow releases	A3 < NAA/A1 for 22 years A3 = NAA/A1 for 2 years A3 > NAA/A1 for 27 years	A3 < NAA/A1 for 22 years A3 = NAA/A1 for 4 years A3 > NAA/A1 for 18 years	A3 < NAA/A1 for 26 years A3 = NAA/A1 for 3 years A3 > NAA/A1 for 23 years

[1] Differences compared with NAA/A1 include only those years that triggered the USACE 2012 DP and the lower flow release time periods of April – December

4.0 ENVIRONMENTAL AND SOCIOECONOMIC CONSIDERATIONS

4.1 Water Supply

The HEC-ResSim modeling calculated reservoir elevations under the various alternatives. This allows identification of potential impacts to water intakes from the alternatives. The analyses indicate three Clemson University intakes on Hartwell Lake would be affected under some sensitivity analyses, but those intakes are not considered critical intakes because they are not used for drinking water. The City of Lavonia's intake on Hartwell Lake would be affected by A3 and A4. That intake is located at 636 feet AMSL, within the Hartwell Conservation Pool, so it is subject to periods of non-availability during droughts. The City is able to use water from the Crawford Creek reservoir if water from Hartwell is not available. The City plans to add another intake to their pipe in Hartwell and connect to the City of Toccoa's water system. Modeling on the availability of the Lavonia intake only considers the City's present withdrawal (one intake at 636 feet). With the NAA, that intake would not be useful 24 days during the 50-year period of analysis. With A3, the intake would be unavailable 43 days, and with A4 it would be unavailable 41 days. Since this intake is located within the Hartwell Conservation Pool that was designed to be fully drafted during droughts, these additional days on non-availability are deemed to be a minor impact. No other public water supply intake would become inoperable as a result of the alternatives considered. As a result, potential impacts to water supply from the four alternatives are considered negligible.

A2, A3 and A4 include measures to encourage coordinated responses by regional water suppliers during droughts to reduce their consumptive water use. Experience with these measures in the Catawba-Wateree River Basin during the 2007-2009 drought of record resulted in measureable reductions in water use when compared to long-term average.

Differences between alternatives in downstream flow releases from JST are small. No reduction would occur in flow volumes from JST on a given day because USACE would continue to operate under the conditions of its 2012 Drought Plan. As a result, there are no expected impacts to downstream water intakes, including the Savannah River Site, Beaufort-Jasper Water Authority, Vogtle Nuclear Plant, City of Savannah, City of Augusta, Georgia-Pacific Gypsum, Weyerhaeuser Port Wentworth Mill, Georgia Power Plants, International Paper's Augusta Plant, and South Carolina Electric and Gas Urquhart Station. Appendix A contains detailed water withdrawals and returns from a 2012 water supply study of the Savannah River Basin.

4.2 Water Quality

The HEC-ResSim model results provide information on how all four model scenarios affect reservoir drawdown levels and downstream flow releases. From a water quality perspective, reservoir drawdowns primarily impact temperature and D.O. stratification. Modeled reservoir drawdowns are more pronounced for Lakes Jocassee and Keowee and the differences between the alternatives are also more apparent for these two reservoirs. Differences between the alternatives are less pronounced for the USACE reservoirs and for flows released to the Savannah River from JST.

All D.O. data collected by Duke Energy in the Lake Keowee Hydro tailrace as part of the Keowee-Toxaway Project relicensing studies is in compliance with South Carolina water quality standards (daily average of 5.0 mg/L and a daily minimum of 4.0 mg/L). Flow releases from JST Dam generally contain at least 5 mg/L of D.O. This level meets both the Georgia and South Carolina D.O. standards for those waters. Since the flow volumes that USACE would release from JST would not change in any of the alternatives, instantaneous D.O. levels downstream of that site would not differ between alternatives. As a result, the proposed action will not cause or contribute to violations of SC or GA D.O. standards.

The Georgia Department of Natural Resources Environmental Protection Division (DNR-EPD) analyzed the potential effects on water quality in both the river and the Savannah estuary/harbor area associated with a proposed winter flow reduction to 3,100 cfs in 2008. The study concentrated on D.O. levels because the States of Georgia and South Carolina previously identified D.O. as a critical water quality parameter. For the river portion (JST to Clyo) of the basin, Georgia DNR-EPD used the RIV1 Model (one-dimensional dynamic hydraulic and water quality model) to identify potential point source discharge problems along the river if river flow was reduced. The riverine water quality model showed that the 5.0 mg/L D.O. standard would not be violated by a JST flow release of 3,100 cfs or 3,600 cfs. For the estuary/harbor portion of the basin (Clyo to ocean), Georgia DNR-EPD used the EFDC (Environmental Fluid Dynamics Code) and WASP (Water Quality Analysis Simulation Program) Models. The harbor water quality model showed that the 5.0 mg/L D.O. standard could be violated by a JST flow release of both 3,100 cfs and 3,600 cfs from April through December. This is the result of lower D.O. levels that are regularly experienced in the estuary during the warmer months.

As described in Section 3.3.3, the USACE Drought Plan includes provisions to increase JST flow releases during the winter months during droughts if the State of Georgia or South Carolina notifies USACE of unacceptable water quality conditions. USACE would then increase JST flow releases to as high as 3,800 cfs to address those observed unacceptable conditions.

To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor, each action alternative includes a provision where USACE and Duke Energy would discharge 200 cubic feet per second of water above that specified in the Drought Plan from their dams for 11 days when the USACE reservoirs are in drought status during the summer months.

4.3 Recreation

The HEC ResSim model calculates reservoir elevations for operation under each of the alternatives. This section addresses potential impacts to recreation resources (i.e., boating and swimming) from changes in pool elevations. Daily reservoir elevations were evaluated for potential impacts to public boat ramps and swimming areas at both the Duke Energy and USACE reservoirs. The 73-year POR was separated into calendar quarters to identify the effect on reservoir elevations during specific times of the year.

4.3.1 *Public Boat-Launching Ramps on the Reservoirs*

4.3.1.1 *Duke Energy Reservoirs*

Duke Energy provides nine public boat ramps on Lake Jocassee and twenty-four public boat ramps on Lake Keowee. Six of the nine public boat ramps on Lake Jocassee become unusable when the reservoir elevation falls below 1,085 feet AMSL. All nine become unusable below 1,080 feet AMSL. The boat ramps on Lake Keowee are unusable at varying reservoir elevations. Two become unusable on Lake Keowee when the reservoir elevation falls below 791 feet AMSL, ten more (total of 12) become unusable below 790 feet AMSL, five more (total of 17) become unusable below 789 feet AMSL, four more (total of 21) become unusable below 788 feet AMSL, and three more (i.e., all 24) become unusable below 787 feet AMSL.

USACE used the ResSim model to calculate reservoir elevations over the 73-year Period of Record. Outputs from that modeling can be used to identify when pool levels would have declined to the point where a given boat ramp would not be available for use. Tables 4.3-1 and 4.3-2 provide the percentage of days and total days, respectively, when the boat ramps are unusable for the future water withdrawals and historic hydrology model runs. To evaluate potential seasonal differences, the table shows both quarterly and annual calculations of days where individual boat ramps are not usable.

For Lake Jocassee there is always at least one boat ramp open at Devils Fork State Park regardless of season or alternative. For Lake Keowee, NAA/A1 results in the most unusable days, although, the magnitude of the impact is small (e.g., an average of 1.41 percent of days in fourth quarter annually and an average of 0.93 percent of days on an annual basis). A3 and A4 result in a very small number of unusable days (e.g., an average of 0.02 percent) on an annual basis.

Sensitivity Analysis: Assuming current water withdrawals instead of future water withdrawals results in zero days where a boat ramp is not available on Lake Jocassee and the unusable days for NAA/A1 at Lake Keowee drop to 0.34 percent on an annual basis. See Tables N-1 and N-2 in Appendix N for detailed results.

Using climate change hydrology instead of historic hydrology results in five days where a boat ramp is not available on Lake Jocassee. For Lake Keowee, climate change hydrology conditions result in a slight increase of unusable days compared to historic hydrology. See Tables N-3 and N-4 in Appendix N for detailed results.

4.3.1.2 *USACE Reservoirs*

There are 111 public boat ramps on Hartwell Lake and 102 public boat ramps and marinas on JST Lake. Boat ramps at Hartwell Lake start becoming unusable at elevations below 658 feet AMSL and all boat ramps are unusable at elevations below 638 feet AMSL. In JST Lake, all boat ramps are usable until the reservoir falls below 326 feet AMSL. However, when the reservoir is at or below 306 feet AMSL, none of these boat ramps are available. At RBR Lake, none of the boat ramps are unusable under any of the alternatives considered.

Tables 4.3-3 and 4.3-4 provide the percentage of days and total days, respectively, when boat ramps would be unusable (with future water withdrawals with historic hydrology) at Hartwell Lake. On an annual basis, boat ramps are unavailable 0.16 - 52 percent of the time depending upon the ramp and the modeling scenario. The difference in number of days when individual boat ramps are unusable is typically in the one to two percent range for all modeled alternatives. In general, A4 results in the largest number of unusable days and A2 results in the fewest. On a quarterly basis, each season mimics the annual statistics in differences between model scenarios, however, the magnitude of differences changes seasonally. Again, A4 typically has the largest number of unusable days.

Tables 4.3-5 and 4.3-6 provide the percentage of days and total days, respectively, when boat ramps are unusable (with future water withdrawals with historic hydrology) at JST Lake. On an annual basis, boat ramps are unavailable up to 26.4 percent of the time depending upon the ramp and alternative. The differences in number of days when individual boat ramps are unusable on JST Lake are less than it is for Hartwell Lake and typically less than one percent. On a quarterly basis, only the months of October through December have results that differ slightly from the annual statistics. During the fourth quarter, differences between modeled scenarios are as large as 3 percent with A4 generally resulting in the largest number of unusable days.

Model Sensitivity Analysis: For Hartwell Lake, using current water withdrawals instead of future water withdrawals results in fewer unusable ramp days, with differences of unusable days between alternatives typically in the zero to two percent range. The October through December timeframe exhibits differences up to four percent for a few boat ramps. For both the annual and seasonal statistics, A4 typically results in the highest number of unusable days and NAA/A1 results in the lowest. However, differences between alternatives are minimal over the POR. See Tables N-5 and N-6 in Appendix N for detailed results.

For JST Lake, modeling current water withdrawals also results in fewer unusable ramp days with incremental differences between alternatives of less than one percent. See Tables N-7 and N-8 in Appendix N for detailed results.

Table 4.3-1 Percentage of Days Boat Ramps are Unusable on Lake Jocassee and Lake Keowee (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Development	Access Area Name	County	Not usable below elevation* (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Jocassee	Devils Fork State Park	Oconee	1080.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Keowee	Warpath	Pickens	789.0	1.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.82%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	0.87%	0.00%	0.00%	0.00%
	Cane Creek	Oconee	789.0	1.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.82%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	0.87%	0.00%	0.00%	0.00%
	Stamp Creek	Oconee	788.0	1.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.49%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	0.78%	0.00%	0.00%	0.00%
	Keowee Town	Oconee	790.0	1.37%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%	0.00%	1.01%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	1.03%	0.00%	0.00%	0.00%
	Fall Creek	Oconee	790.0	1.37%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%	0.00%	1.01%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	1.03%	0.00%	0.00%	0.00%
	Crow Creek	Pickens	788.0	1.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.49%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	0.78%	0.00%	0.00%	0.00%
	South Cove Park	Oconee	787.0	1.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	0.64%	0.00%	0.00%	0.00%
	High Falls Park	Oconee	791.0	1.37%	0.00%	0.24%	0.39%	0.68%	0.00%	0.00%	0.00%	1.44%	0.00%	0.06%	0.09%	1.77%	0.00%	0.24%	0.70%	1.32%	0.00%	0.14%	0.30%
	Mile Creek Park	Pickens	790.0	1.37%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%	0.00%	1.01%	0.00%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%	1.03%	0.00%	0.00%	0.00%

* The elevation below which ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation.

Table 4.3-2 Number of Days Boat Ramps are Unusable on Lake Jocassee and Lake Keowee (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Development	Access Area Name	County	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Jocassee	Devils Fork State Park	Oconee	1080.0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Keowee	Warpath	Pickens	789.0	85	0	0	0	0	0	0	0	55	0	0	0	92	0	0	0	232	0	0	0
	Cane Creek	Oconee	789.0	85	0	0	0	0	0	0	0	55	0	0	0	92	0	0	0	232	0	0	0
	Stamp Creek	Oconee	788.0	82	0	0	0	0	0	0	0	33	0	0	0	92	0	0	0	207	0	0	0
	Keowee Town	Oconee	790.0	90	0	0	0	25	0	0	0	68	0	0	0	92	0	0	0	275	0	0	0
	Fall Creek	Oconee	790.0	90	0	0	0	25	0	0	0	68	0	0	0	92	0	0	0	275	0	0	0
	Crow Creek	Pickens	788.0	82	0	0	0	0	0	0	0	33	0	0	0	92	0	0	0	207	0	0	0
	South Cove Park	Oconee	787.0	67	0	0	0	0	0	0	0	12	0	0	0	92	0	0	0	171	0	0	0
	High Falls Park	Oconee	791.0	90	0	16	26	45	0	0	0	97	0	4	6	119	0	16	47	351	0	36	79
	Mile Creek Park	Pickens	790.0	90	0	0	0	25	0	0	0	68	0	0	0	92	0	0	0	275	0	0	0

* The elevation below which ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation.

Table 4.3-3 Percentage of Days Boat Ramps are Unusable on Hartwell Lake (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Sadler’s Creek State Park	SC	1	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Tugaloo State Park	GA	2	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Jack’s Landing	SC	1	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Holder’s Access	SC	1	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Lakeshore	SC	1	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Mountain Bay	SC	1	658.0	58.32%	58.18%	59.27%	59.58%	18.09%	18.30%	19.06%	19.18%	49.57%	49.46%	51.01%	51.31%	81.40%	81.04%	82.01%	82.08%	51.91%	51.81%	52.90%	53.10%
Reed Creek	GA	1	657.5	51.17%	51.00%	52.91%	52.88%	15.72%	15.76%	16.06%	16.27%	39.29%	39.07%	42.14%	42.56%	75.06%	74.76%	75.65%	75.73%	45.36%	45.20%	46.74%	46.91%
Rocky Ford	GA	1	657.5	51.17%	51.00%	52.91%	52.88%	15.72%	15.76%	16.06%	16.27%	39.29%	39.07%	42.14%	42.56%	75.06%	74.76%	75.65%	75.73%	45.36%	45.20%	46.74%	46.91%
Brown Road	SC	1	657.0	43.70%	43.62%	45.45%	45.45%	13.16%	13.22%	13.71%	13.83%	29.66%	29.44%	34.07%	34.46%	68.31%	67.91%	69.62%	69.72%	38.75%	38.59%	40.76%	40.92%
Hurricane Creek	SC	1	657.0	43.70%	43.62%	45.45%	45.45%	13.16%	13.22%	13.71%	13.83%	29.66%	29.44%	34.07%	34.46%	68.31%	67.91%	69.62%	69.72%	38.75%	38.59%	40.76%	40.92%
Seneca Creek	SC	1	657.0	43.70%	43.62%	45.45%	45.45%	13.16%	13.22%	13.71%	13.83%	29.66%	29.44%	34.07%	34.46%	68.31%	67.91%	69.62%	69.72%	38.75%	38.59%	40.76%	40.92%
Walker Creek	GA	1	657.0	43.70%	43.62%	45.45%	45.45%	13.16%	13.22%	13.71%	13.83%	29.66%	29.44%	34.07%	34.46%	68.31%	67.91%	69.62%	69.72%	38.75%	38.59%	40.76%	40.92%
Cove Inlet	SC	1	656.5	36.51%	36.48%	38.43%	38.59%	11.71%	11.71%	12.16%	12.34%	24.42%	24.51%	28.54%	28.96%	61.06%	60.80%	63.48%	63.47%	33.47%	33.42%	35.71%	35.89%
Durham	SC	1	655.7	25.32%	25.33%	26.96%	27.03%	10.12%	10.07%	10.28%	10.21%	19.33%	19.43%	22.41%	22.75%	41.91%	41.61%	47.24%	47.33%	24.20%	24.14%	26.76%	26.87%
South Union	SC	1	655.5	24.48%	24.56%	25.93%	26.12%	9.66%	9.57%	9.94%	9.80%	18.70%	18.78%	21.49%	21.74%	40.27%	39.94%	45.57%	45.99%	23.31%	23.24%	25.77%	25.95%
Bradberry	GA	1	655.0	22.47%	22.48%	24.30%	24.48%	8.93%	8.81%	9.26%	9.21%	17.24%	17.38%	19.43%	19.58%	36.55%	36.26%	41.86%	42.34%	21.32%	21.26%	23.75%	23.94%
Timberland	SC	1	654.0	16.36%	16.06%	18.99%	19.11%	7.38%	6.44%	7.39%	7.41%	13.59%	13.70%	15.38%	15.43%	29.59%	29.38%	34.58%	34.76%	16.76%	16.42%	19.12%	19.21%
Darvin Wright City Park	SC	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
Tillies	SC	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
White City	SC	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
Barton Mill	SC	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
Port Bass	SC	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
Seymour	GA	1	653.0	11.57%	11.58%	12.83%	12.84%	4.95%	4.28%	5.19%	5.30%	9.81%	9.65%	10.33%	10.54%	20.48%	20.22%	25.39%	25.03%	11.72%	11.45%	13.46%	13.45%
Payne’s Creek (inner right)	GA	1	652.6	10.03%	10.08%	10.69%	10.82%	4.65%	3.97%	4.80%	4.85%	9.17%	8.89%	9.51%	9.56%	17.90%	17.71%	21.06%	21.07%	10.46%	10.18%	11.54%	11.60%
Payne’s Creek (left)	GA	1	652.6	10.03%	10.08%	10.69%	10.82%	4.65%	3.97%	4.80%	4.85%	9.17%	8.89%	9.51%	9.56%	17.90%	17.71%	21.06%	21.07%	10.46%	10.18%	11.54%	11.60%
Big Oak (left lane)	GA	1	652.5	9.61%	9.62%	10.20%	10.32%	4.64%	3.84%	4.73%	4.70%	9.05%	8.68%	9.37%	9.43%	17.32%	16.99%	20.00%	20.03%	10.17%	9.80%	11.09%	11.14%
Tabor	SC	1	652.5	9.61%	9.62%	10.20%	10.32%	4.64%	3.84%	4.73%	4.70%	9.05%	8.68%	9.37%	9.43%	17.32%	16.99%	20.00%	20.03%	10.17%	9.80%	11.09%	11.14%
Townville	SC	1	652.3	8.33%	8.38%	9.17%	9.35%	4.47%	3.73%	4.59%	4.58%	8.71%	8.25%	9.11%	9.16%	16.41%	16.07%	18.35%	18.56%	9.50%	9.13%	10.33%	10.43%
Apple Island	SC	1	651.5	7.23%	7.18%	7.71%	7.76%	4.02%	2.88%	4.26%	4.25%	7.31%	6.60%	7.83%	7.85%	12.78%	12.35%	15.07%	15.06%	7.85%	7.26%	8.74%	8.74%
Poplar Spring (left ramp)	GA	1	651.5	7.23%	7.18%	7.71%	7.76%	4.02%	2.88%	4.26%	4.25%	7.31%	6.60%	7.83%	7.85%	12.78%	12.35%	15.07%	15.06%	7.85%	7.26%	8.74%	8.74%
Stephens Co.	GA	1	651.5	7.23%	7.18%	7.71%	7.76%	4.02%	2.88%	4.26%	4.25%	7.31%	6.60%	7.83%	7.85%	12.78%	12.35%	15.07%	15.06%	7.85%	7.26%	8.74%	8.74%
Broyles (East ramp)	SC	1	651.3	7.16%	7.09%	7.48%	7.56%	3.79%	2.60%	4.02%	4.05%	6.94%	6.21%	7.40%	7.64%	12.41%	11.93%	14.48%	14.50%	7.59%	6.97%	8.36%	8.45%
Friendship (left lane)	SC	1	651.0	6.98%	6.86%	7.33%	7.35%	3.42%	2.36%	3.72%	3.73%	6.60%	5.66%	7.00%	7.07%	12.15%	11.51%	13.57%	13.64%	7.30%	6.61%	7.92%	7.96%
Lawrence Bridge	SC	1	651.0	6.98%	6.86%	7.33%	7.35%	3.42%	2.36%	3.72%	3.73%	6.60%	5.66%	7.00%	7.07%	12.15%	11.51%	13.57%	13.64%	7.30%	6.61%	7.92%	7.96%

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
River Fork (right ramp)	SC	1	651.0	6.98%	6.86%	7.33%	7.35%	3.42%	2.36%	3.72%	3.73%	6.60%	5.66%	7.00%	7.07%	12.15%	11.51%	13.57%	13.64%	7.30%	6.61%	7.92%	7.96%
Broyles (West ramp)	SC	1	650.5	6.45%	6.24%	7.12%	7.12%	3.06%	2.05%	3.16%	3.19%	5.99%	4.90%	6.36%	6.39%	11.53%	11.14%	12.11%	12.30%	6.77%	6.09%	7.20%	7.26%
Jarrett	SC	1	650.0	6.06%	5.94%	6.63%	6.69%	2.91%	1.25%	3.01%	3.04%	5.61%	4.41%	5.85%	5.96%	10.57%	10.31%	11.38%	11.65%	6.30%	5.48%	6.73%	6.84%
Holcomb	GA	1	650.0	6.06%	5.94%	6.63%	6.69%	2.91%	1.25%	3.01%	3.04%	5.61%	4.41%	5.85%	5.96%	10.57%	10.31%	11.38%	11.65%	6.30%	5.48%	6.73%	6.84%
Cleveland	GA	1	649.5	5.75%	5.13%	6.03%	6.06%	2.32%	0.80%	2.48%	2.63%	5.33%	4.01%	5.20%	5.30%	9.14%	8.79%	10.62%	10.83%	5.64%	4.69%	6.09%	6.21%
Spring Branch	GA	1	649.0	4.33%	4.05%	5.59%	5.66%	1.90%	0.50%	1.78%	1.94%	4.35%	3.51%	4.54%	4.72%	7.59%	7.45%	9.83%	10.05%	4.55%	3.89%	5.44%	5.60%
Honea Path	SC	1	648.5	3.72%	3.60%	5.04%	5.13%	1.51%	0.33%	1.49%	1.49%	3.48%	2.92%	3.96%	4.05%	6.79%	6.60%	8.53%	8.73%	3.88%	3.37%	4.76%	4.86%
Twin Lakes (right ramp)	SC	1	648.0	3.57%	3.37%	4.14%	4.16%	1.22%	0.23%	1.25%	1.29%	2.89%	2.58%	3.26%	3.45%	5.29%	5.27%	7.10%	7.36%	3.24%	2.87%	3.95%	4.07%
Twin Lakes (left ramp)	SC	1	648.0	3.57%	3.37%	4.14%	4.16%	1.22%	0.23%	1.25%	1.29%	2.89%	2.58%	3.26%	3.45%	5.29%	5.27%	7.10%	7.36%	3.24%	2.87%	3.95%	4.07%
Fairplay (left lane)	SC	1	647.0	2.53%	1.97%	3.35%	3.42%	0.87%	0.08%	0.92%	0.93%	2.28%	2.22%	2.47%	2.61%	3.90%	3.93%	5.27%	5.51%	2.40%	2.06%	3.01%	3.12%
Twelve Mile (left lane)	SC	1	647.0	2.53%	1.97%	3.35%	3.42%	0.87%	0.08%	0.92%	0.93%	2.28%	2.22%	2.47%	2.61%	3.90%	3.93%	5.27%	5.51%	2.40%	2.06%	3.01%	3.12%
Twelve Mile (right lane)	SC	1	647.0	2.53%	1.97%	3.35%	3.42%	0.87%	0.08%	0.92%	0.93%	2.28%	2.22%	2.47%	2.61%	3.90%	3.93%	5.27%	5.51%	2.40%	2.06%	3.01%	3.12%
Clemson	SC	1	645.5	1.37%	0.91%	1.70%	1.73%	0.59%	0.00%	0.56%	0.57%	1.47%	1.38%	1.79%	1.82%	1.67%	2.00%	3.11%	3.08%	1.28%	1.08%	1.79%	1.80%
Milltown	GA	1	645.4	1.37%	0.88%	1.59%	1.62%	0.56%	0.00%	0.53%	0.56%	1.41%	1.35%	1.76%	1.80%	1.53%	1.94%	2.89%	2.92%	1.22%	1.05%	1.70%	1.73%
Carters Ferry	GA	1	645.0	1.37%	0.65%	1.37%	1.37%	0.44%	0.00%	0.44%	0.50%	1.10%	1.22%	1.52%	1.58%	1.37%	1.76%	2.43%	2.47%	1.07%	0.91%	1.44%	1.48%
Watsadler	GA	1	645.0	1.37%	0.65%	1.37%	1.37%	0.44%	0.00%	0.44%	0.50%	1.10%	1.22%	1.52%	1.58%	1.37%	1.76%	2.43%	2.47%	1.07%	0.91%	1.44%	1.48%
Big Oaks (right lane)	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Camp Creek	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Choestoea	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Coneross	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Double Spring	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Duncan Branch	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Fairplay (right lane)	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Friendship (right lane)	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Glenn Ferry	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Green Pond	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Hatton's Ford	SC	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Long Point	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
New Prospect	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Rock Spring	GA	1	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Gum Branch	GA	6	644.0	1.32%	0.30%	1.32%	1.35%	0.00%	0.00%	0.00%	0.00%	0.89%	0.89%	1.16%	1.25%	1.37%	1.44%	1.37%	1.40%	0.90%	0.66%	0.96%	1.00%
Poplar Spring (right ramp)	GA	1	643.6	1.29%	0.23%	1.31%	1.32%	0.00%	0.00%	0.00%	0.00%	0.83%	0.88%	0.95%	1.07%	1.37%	1.40%	1.37%	1.37%	0.87%	0.63%	0.91%	0.94%
Springfield	SC	1	643.6	1.29%	0.23%	1.31%	1.32%	0.00%	0.00%	0.00%	0.00%	0.83%	0.88%	0.95%	1.07%	1.37%	1.40%	1.37%	1.37%	0.87%	0.63%	0.91%	0.94%
Crawford Ferry	GA	1	643.3	1.29%	0.21%	1.29%	1.31%	0.00%	0.00%	0.00%	0.00%	0.76%	0.82%	0.94%	0.94%	1.37%	1.37%	1.37%	1.37%	0.86%	0.60%	0.90%	0.90%

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Asbury (camping)	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Denver	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Eighteen Mile Creek	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Elrod Ferry	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Jenkins Ferry	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Martin Creek	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Mary Ann Branch	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Oconee Point	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Paynes Creek (outer)	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Powder Bag Creek N	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Richland Creek	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
River Forks (left ramp)	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Singing Pines	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Weldon Island	SC	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Harbor Light Marina	GA	2	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Hartwell Marina	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Hart State Park	GA	2	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Portman Shoals	GA	1	643.0	1.28%	0.12%	1.29%	1.29%	0.00%	0.00%	0.00%	0.00%	0.76%	0.71%	0.91%	0.94%	1.37%	1.37%	1.37%	1.37%	0.85%	0.56%	0.89%	0.90%
Broyles (middle ramp)	SC	1	642.0	1.15%	0.02%	1.23%	1.26%	0.00%	0.00%	0.00%	0.00%	0.55%	0.63%	0.73%	0.74%	1.37%	1.34%	1.37%	1.37%	0.77%	0.50%	0.83%	0.84%
Tugaloo State Park (mega)	GA	6	642.0	1.15%	0.02%	1.23%	1.26%	0.00%	0.00%	0.00%	0.00%	0.55%	0.63%	0.73%	0.74%	1.37%	1.34%	1.37%	1.37%	0.77%	0.50%	0.83%	0.84%
Mullins Ford	SC	1	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%
Big Water	SC	1	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%
Bruce Creek	GA	1	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%
Lake Hartwell State Park	SC	2	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%
Lightwood Log Creek	GA	1	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%
Sadlers Creek State Park #1	SC	2	638.0	0.47%	0.00%	0.50%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.09%	1.37%	0.64%	1.37%	1.37%	0.46%	0.16%	0.48%	0.59%

* The elevation below which ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation.

Table 4.3-4 Number of Days Boat Ramps are Unusable on Hartwell Lake (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Sadler's Creek State Park	SC	1	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Tugaloo State Park	GA	2	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Jack's Landing	SC	1	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Holder's Access	SC	1	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Lakeshore	SC	1	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Mountain Bay	SC	1	658.0	3,842	3,833	3,905	3,925	1,202	1,216	1,266	1,274	3,329	3,322	3,426	3,446	5,466	5,442	5,507	5,512	13,839	13,813	14,104	14,157
Reed Creek	GA	1	657.5	3,371	3,360	3,486	3,484	1,044	1,047	1,067	1,081	2,639	2,624	2,830	2,858	5,040	5,020	5,080	5,085	12,094	12,051	12,463	12,508
Rocky Ford	GA	1	657.5	3,371	3,360	3,486	3,484	1,044	1,047	1,067	1,081	2,639	2,624	2,830	2,858	5,040	5,020	5,080	5,085	12,094	12,051	12,463	12,508
Brown Road	SC	1	657.0	2,879	2,874	2,994	2,994	874	878	911	919	1,992	1,977	2,288	2,314	4,587	4,560	4,675	4,682	10,332	10,289	10,868	10,909
Hurricane Creek	SC	1	657.0	2,879	2,874	2,994	2,994	874	878	911	919	1,992	1,977	2,288	2,314	4,587	4,560	4,675	4,682	10,332	10,289	10,868	10,909
Seneca Creek	SC	1	657.0	2,879	2,874	2,994	2,994	874	878	911	919	1,992	1,977	2,288	2,314	4,587	4,560	4,675	4,682	10,332	10,289	10,868	10,909
Walker Creek	GA	1	657.0	2,879	2,874	2,994	2,994	874	878	911	919	1,992	1,977	2,288	2,314	4,587	4,560	4,675	4,682	10,332	10,289	10,868	10,909
Cove Inlet	SC	1	656.5	2,405	2,403	2,532	2,542	778	778	808	820	1,640	1,646	1,917	1,945	4,100	4,083	4,263	4,262	8,923	8,910	9,520	9,569
Durham	SC	1	655.7	1,668	1,669	1,776	1,781	672	669	683	678	1,298	1,305	1,505	1,528	2,814	2,794	3,172	3,178	6,452	6,437	7,136	7,165
South Union	SC	1	655.5	1,613	1,618	1,708	1,721	642	636	660	651	1,256	1,261	1,443	1,460	2,704	2,682	3,060	3,088	6,215	6,197	6,871	6,920
Bradberry	GA	1	655.0	1,480	1,481	1,601	1,613	593	585	615	612	1,158	1,167	1,305	1,315	2,454	2,435	2,811	2,843	5,685	5,668	6,332	6,383
Timberland	SC	1	654.0	1,078	1,058	1,251	1,259	490	428	491	492	913	920	1,033	1,036	1,987	1,973	2,322	2,334	4,468	4,379	5,097	5,121
Darvin Wright City Park	SC	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
Tillies	SC	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
White City	SC	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
Barton Mill	SC	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
Port Bass	SC	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
Seymour	GA	1	653.0	762	763	845	846	329	284	345	352	659	648	694	708	1,375	1,358	1,705	1,681	3,125	3,053	3,589	3,587
Payne's Creek (inner right)	GA	1	652.6	661	664	704	713	309	264	319	322	616	597	639	642	1,202	1,189	1,414	1,415	2,788	2,714	3,076	3,092
Payne's Creek (left)	GA	1	652.6	661	664	704	713	309	264	319	322	616	597	639	642	1,202	1,189	1,414	1,415	2,788	2,714	3,076	3,092
Big Oak (left lane)	GA	1	652.5	633	634	672	680	308	255	314	312	608	583	629	633	1,163	1,141	1,343	1,345	2,712	2,613	2,958	2,970
Tabor	SC	1	652.5	633	634	672	680	308	255	314	312	608	583	629	633	1,163	1,141	1,343	1,345	2,712	2,613	2,958	2,970
Townville	SC	1	652.3	549	552	604	616	297	248	305	304	585	554	612	615	1,102	1,079	1,232	1,246	2,533	2,433	2,753	2,781
Apple Island	SC	1	651.5	476	473	508	511	267	191	283	282	491	443	526	527	858	829	1,012	1,011	2,092	1,936	2,329	2,331
Poplar Spring (left ramp)	GA	1	651.5	476	473	508	511	267	191	283	282	491	443	526	527	858	829	1,012	1,011	2,092	1,936	2,329	2,331
Stephens Co.	GA	1	651.5	476	473	508	511	267	191	283	282	491	443	526	527	858	829	1,012	1,011	2,092	1,936	2,329	2,331
Broyles (East ramp)	SC	1	651.3	472	467	493	498	252	173	267	269	466	417	497	513	833	801	972	974	2,023	1,858	2,229	2,254
Friendship (left lane)	SC	1	651.0	460	452	483	484	227	157	247	248	443	380	470	475	816	773	911	916	1,946	1,762	2,111	2,123
Lawrence Bridge	SC	1	651.0	460	452	483	484	227	157	247	248	443	380	470	475	816	773	911	916	1,946	1,762	2,111	2,123
River Fork (right ramp)	SC	1	651.0	460	452	483	484	227	157	247	248	443	380	470	475	816	773	911	916	1,946	1,762	2,111	2,123

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Broyles (West ramp)	SC	1	650.5	425	411	469	469	203	136	210	212	402	329	427	429	774	748	813	826	1,804	1,624	1,919	1,936
Jarrett	SC	1	650.0	399	391	437	441	193	83	200	202	377	296	393	400	710	692	764	782	1,679	1,462	1,794	1,825
Holcomb	GA	1	650.0	399	391	437	441	193	83	200	202	377	296	393	400	710	692	764	782	1,679	1,462	1,794	1,825
Cleveland	GA	1	649.5	379	338	397	399	154	53	165	175	358	269	349	356	614	590	713	727	1,505	1,250	1,624	1,657
Spring Branch	GA	1	649.0	285	267	368	373	126	33	118	129	292	236	305	317	510	500	660	675	1,213	1,036	1,451	1,494
Honea Path	SC	1	648.5	245	237	332	338	100	22	99	99	234	196	266	272	456	443	573	586	1,035	898	1,270	1,295
Twin Lakes (right ramp)	SC	1	648.0	235	222	273	274	81	15	83	86	194	173	219	232	355	354	477	494	865	764	1,052	1,086
Twin Lakes (left ramp)	SC	1	648.0	235	222	273	274	81	15	83	86	194	173	219	232	355	354	477	494	865	764	1,052	1,086
Fairplay (left lane)	SC	1	647.0	167	130	221	225	58	5	61	62	153	149	166	175	262	264	354	370	640	548	802	832
Twelve Mile (left lane)	SC	1	647.0	167	130	221	225	58	5	61	62	153	149	166	175	262	264	354	370	640	548	802	832
Twelve Mile (right lane)	SC	1	647.0	167	130	221	225	58	5	61	62	153	149	166	175	262	264	354	370	640	548	802	832
Clemson	SC	1	645.5	90	60	112	114	39	0	37	38	99	93	120	122	112	134	209	207	340	287	478	481
Milltown	GA	1	645.4	90	58	105	107	37	0	35	37	95	91	118	121	103	130	194	196	325	279	452	461
Carters Ferry	GA	1	645.0	90	43	90	90	29	0	29	33	74	82	102	106	92	118	163	166	285	243	384	395
Watsadler	GA	1	645.0	90	43	90	90	29	0	29	33	74	82	102	106	92	118	163	166	285	243	384	395
Big Oaks (right lane)	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Camp Creek	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Choestoea	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Coneross	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Double Spring	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Duncan Branch	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Fairplay (right lane)	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Friendship (right lane)	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Glenn Ferry	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Green Pond	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Hatton's Ford	SC	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Long Point	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
New Prospect	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Rock Spring	GA	1	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Gum Branch	GA	6	644.0	87	20	87	89	0	0	0	0	60	60	78	84	92	97	92	94	239	177	257	267
Poplar Spring (right ramp)	GA	1	643.6	85	15	86	87	0	0	0	0	56	59	64	72	92	94	92	92	233	168	242	251
Springfield	SC	1	643.6	85	15	86	87	0	0	0	0	56	59	64	72	92	94	92	92	233	168	242	251
Crawford Ferry	GA	1	643.3	85	14	85	86	0	0	0	0	51	55	63	63	92	92	92	92	228	161	240	241
Asbury (camping)	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Denver	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Eighteen Mile Creek	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Elrod Ferry	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Jenkins Ferry	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Martin Creek	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Mary Ann Branch	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Oconee Point	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Paynes Creek (outer)	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Powder Bag Creek N	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Richland Creek	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
River Forks (left ramp)	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Singing Pines	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Weldon Island	SC	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Harbor Light Marina	GA	2	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Hartwell Marina	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Hart State Park	GA	2	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Portman Shoals	GA	1	643.0	84	8	85	85	0	0	0	0	51	48	61	63	92	92	92	92	227	148	238	240
Broyles (middle ramp)	SC	1	642.0	76	1	81	83	0	0	0	0	37	42	49	50	92	90	92	92	205	133	222	225
Tugaloo State Park (mega)	GA	6	642.0	76	1	81	83	0	0	0	0	37	42	49	50	92	90	92	92	205	133	222	225
Mullins Ford	SC	1	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156
Big Water	SC	1	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156
Bruce Creek	GA	1	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156
Lake Hartwell State Park	SC	2	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156
Lightwood Log Creek	GA	1	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156
Sadlers Creek State Park #1	SC	2	638.0	31	0	33	58	0	0	0	0	0	0	2	6	92	43	92	92	123	43	127	156

* The elevation below which ramps may not be usable for most boats is presented as three feet above the top of the concrete ramp end elevation.

Table 4.3-5 Percentage of Days Boat Ramps are Unusable on JST Lake (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Boat Ramp Name	State	No. of Lanes	Not usable below elevation * (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Hwy 28 Access Road	SC	1	326.0	23.42%	23.44%	21.30%	21.34%	11.38%	11.62%	11.15%	11.38%	21.19%	20.80%	22.77%	23.33%	49.34%	49.53%	45.05%	45.39%	26.39%	26.40%	25.12%	25.42%
Long Cane Creek Ramp	SC	1	325.7	18.61%	18.70%	17.27%	17.44%	10.06%	10.34%	9.92%	10.31%	18.02%	17.76%	17.97%	18.52%	38.42%	38.66%	36.35%	36.47%	21.32%	21.41%	20.42%	20.73%
Catfish Ramp	SC	1	325.5	16.09%	16.26%	15.98%	16.24%	9.11%	9.51%	9.15%	9.50%	15.99%	15.86%	15.74%	16.26%	32.70%	33.00%	31.94%	32.26%	18.51%	18.69%	18.24%	18.60%
Calhoun Falls Ramp	SC	1	325.0	13.46%	13.81%	14.19%	14.42%	7.69%	7.78%	7.59%	7.81%	13.70%	13.74%	14.03%	14.09%	25.81%	25.67%	26.66%	27.04%	15.19%	15.28%	15.64%	15.87%
Broad River Campground	GA	1	325.0	13.46%	13.81%	14.19%	14.42%	7.69%	7.78%	7.59%	7.81%	13.70%	13.74%	14.03%	14.09%	25.81%	25.67%	26.66%	27.04%	15.19%	15.28%	15.64%	15.87%
Cherokee Recreation Area	GA	5	324.7	12.25%	12.48%	12.93%	13.02%	6.83%	6.89%	6.83%	7.21%	13.22%	13.30%	13.64%	13.62%	23.93%	23.63%	24.80%	25.12%	14.09%	14.10%	14.58%	14.77%
Mistletoe State Park 1 & 2	GA	2	324.2	9.85%	10.09%	10.79%	11.02%	5.83%	5.61%	6.10%	6.26%	12.37%	12.37%	12.89%	12.94%	21.65%	21.27%	22.58%	22.87%	12.46%	12.37%	13.12%	13.30%
Soap Creek Park	GA	1	324.0	9.14%	9.24%	10.06%	10.23%	5.61%	5.36%	5.75%	5.90%	12.03%	12.05%	12.55%	12.63%	20.79%	20.42%	22.11%	22.41%	11.92%	11.80%	12.65%	12.82%
Little River Quarry Ramp	SC	1	324.0	9.14%	9.24%	10.06%	10.23%	5.61%	5.36%	5.75%	5.90%	12.03%	12.05%	12.55%	12.63%	20.79%	20.42%	22.11%	22.41%	11.92%	11.80%	12.65%	12.82%
Lakeside Subdivision Ramp	GA	1	324.0	9.14%	9.24%	10.06%	10.23%	5.61%	5.36%	5.75%	5.90%	12.03%	12.05%	12.55%	12.63%	20.79%	20.42%	22.11%	22.41%	11.92%	11.80%	12.65%	12.82%
Scotts Ferry (new ramp) 1 & 2	SC	2	323.8	8.65%	8.70%	9.56%	9.78%	5.24%	4.58%	5.40%	5.51%	11.61%	11.76%	12.24%	12.34%	20.04%	19.78%	21.59%	21.97%	11.42%	11.23%	12.23%	12.43%
Clay Hill Campground	GA	1	323.5	8.30%	8.33%	9.23%	9.47%	4.34%	3.84%	4.74%	4.86%	11.05%	10.96%	11.58%	11.78%	18.73%	18.44%	20.73%	21.28%	10.63%	10.42%	11.60%	11.88%
Winfield Subdivision	GA	1	323.1	7.95%	7.89%	8.74%	8.99%	3.55%	3.45%	3.78%	3.91%	10.08%	10.02%	10.54%	10.90%	17.11%	16.87%	18.99%	19.99%	9.70%	9.58%	10.54%	10.97%
Mt Pleasant Ramp	SC	1	322.4	7.39%	7.39%	7.56%	7.71%	3.06%	3.00%	3.13%	3.16%	8.80%	8.67%	9.17%	9.26%	15.53%	15.40%	16.32%	16.84%	8.72%	8.63%	9.07%	9.27%
Wildwood Park 5 & 6	GA	2	322.0	7.16%	7.16%	7.32%	7.33%	2.88%	2.68%	2.91%	2.94%	8.07%	7.80%	8.58%	8.73%	14.37%	14.37%	15.28%	15.40%	8.14%	8.02%	8.54%	8.62%
Morrahs Ramp	GA	1	321.5	7.00%	6.94%	7.01%	7.01%	2.48%	2.05%	2.83%	2.81%	7.16%	6.82%	7.58%	7.67%	12.75%	12.72%	13.55%	13.60%	7.36%	7.15%	7.76%	7.79%
Bussey Point	GA	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Chamberlain Ferry Ramp	GA	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Modoc Campground	SC	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Murray Creek Ramp	GA	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Parkway Ramp	GA	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Cherokee Recreation Area 4	GA	1	321.0	6.80%	6.74%	6.91%	6.92%	1.90%	1.87%	2.03%	2.15%	6.39%	5.90%	6.80%	6.95%	11.84%	11.48%	12.15%	12.20%	6.74%	6.51%	6.99%	7.07%
Fishing Creek / Hwy 79 Ramp	GA	1	320.7	6.47%	6.39%	6.74%	6.75%	1.76%	1.76%	1.91%	1.93%	6.03%	5.43%	6.33%	6.40%	11.47%	11.23%	11.76%	11.78%	6.44%	6.21%	6.70%	6.73%
Wildwood Park 3 & 4	GA	2	320.0	5.98%	5.90%	6.13%	6.16%	1.61%	1.45%	1.67%	1.69%	5.20%	4.53%	5.54%	5.66%	10.51%	10.31%	11.08%	11.09%	5.84%	5.55%	6.12%	6.16%

Boat Ramp Name	State	No. of Lanes	Not usable below elevation * (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Maxim Subdivision Ramp	GA	1	320.0	5.98%	5.90%	6.13%	6.16%	1.61%	1.45%	1.67%	1.69%	5.20%	4.53%	5.54%	5.66%	10.51%	10.31%	11.08%	11.09%	5.84%	5.55%	6.12%	6.16%
Wells Creek Subdivision	GA	1	320.0	5.98%	5.90%	6.13%	6.16%	1.61%	1.45%	1.67%	1.69%	5.20%	4.53%	5.54%	5.66%	10.51%	10.31%	11.08%	11.09%	5.84%	5.55%	6.12%	6.16%
Leroys Ferry Campground	SC	1	319.5	5.63%	5.27%	5.83%	5.92%	0.99%	0.90%	1.19%	1.32%	4.78%	4.04%	5.09%	5.18%	9.31%	8.98%	10.10%	10.17%	5.19%	4.80%	5.56%	5.66%
Ridge Road Campground	GA	1	319.0	4.25%	3.79%	4.74%	5.04%	0.53%	0.51%	0.63%	0.74%	4.27%	3.45%	4.62%	4.82%	7.65%	7.45%	8.16%	8.56%	4.19%	3.81%	4.55%	4.80%
Cherokee Recreation Area 3	GA	1	318.7	3.57%	3.46%	3.93%	4.14%	0.45%	0.41%	0.50%	0.54%	3.86%	3.16%	4.21%	4.35%	7.18%	7.09%	7.40%	7.64%	3.77%	3.54%	4.02%	4.18%
Chamberlain Ferry Ramp	GA	1	318.3	3.23%	3.17%	3.38%	3.43%	0.33%	0.32%	0.38%	0.41%	3.32%	2.83%	3.80%	3.93%	6.18%	6.06%	6.75%	6.85%	3.27%	3.10%	3.59%	3.66%
Double Branches Ramp	GA	1	318.1	3.14%	3.13%	3.17%	3.19%	0.29%	0.27%	0.33%	0.36%	3.05%	2.65%	3.47%	3.65%	5.64%	5.58%	6.17%	6.33%	3.04%	2.91%	3.29%	3.39%
Soap Creek Marina	GA	1	318.0	3.11%	3.08%	3.13%	3.14%	0.26%	0.26%	0.30%	0.35%	2.93%	2.61%	3.37%	3.57%	5.41%	5.41%	5.82%	6.08%	2.93%	2.84%	3.16%	3.29%
Cherokee Recreation Area 2	GA	1	318.0	3.11%	3.08%	3.13%	3.14%	0.26%	0.26%	0.30%	0.35%	2.93%	2.61%	3.37%	3.57%	5.41%	5.41%	5.82%	6.08%	2.93%	2.84%	3.16%	3.29%
Amity Recreation Area	GA	1	317.9	3.08%	3.04%	3.10%	3.11%	0.24%	0.24%	0.29%	0.32%	2.84%	2.55%	3.20%	3.41%	5.26%	5.29%	5.63%	5.78%	2.86%	2.78%	3.06%	3.16%
Raysville Marina	GA	1	317.6	2.82%	2.78%	2.94%	3.05%	0.18%	0.18%	0.23%	0.26%	2.64%	2.43%	2.90%	3.01%	4.84%	5.09%	5.17%	5.29%	2.63%	2.63%	2.82%	2.91%
Elbert County Subdivision Ramp	GA	1	317.6	2.82%	2.78%	2.94%	3.05%	0.18%	0.18%	0.23%	0.26%	2.64%	2.43%	2.90%	3.01%	4.84%	5.09%	5.17%	5.29%	2.63%	2.63%	2.82%	2.91%
Modoc Ramp 2	SC	1	317.2	2.35%	2.43%	2.34%	2.43%	0.11%	0.11%	0.15%	0.18%	2.41%	2.26%	2.64%	2.72%	4.29%	4.56%	4.75%	4.85%	2.30%	2.34%	2.48%	2.55%
Soap Creek / Hwy 220 Ramp	GA	1	317.0	2.14%	2.28%	1.73%	1.85%	0.06%	0.06%	0.12%	0.14%	2.32%	2.23%	2.49%	2.62%	4.05%	4.17%	4.48%	4.65%	2.15%	2.19%	2.21%	2.32%
Landam Creek Ramp	SC	1	316.2	0.71%	1.18%	0.90%	0.77%	0.00%	0.00%	0.00%	0.00%	1.98%	2.05%	2.16%	2.17%	2.64%	3.04%	2.68%	2.77%	1.34%	1.58%	1.44%	1.44%
Dordon Creek Ramp	SC	1	316.2	0.71%	1.18%	0.90%	0.77%	0.00%	0.00%	0.00%	0.00%	1.98%	2.05%	2.16%	2.17%	2.64%	3.04%	2.68%	2.77%	1.34%	1.58%	1.44%	1.44%
Hickory Knob State Park	SC	1	316.2	0.71%	1.18%	0.90%	0.77%	0.00%	0.00%	0.00%	0.00%	1.98%	2.05%	2.16%	2.17%	2.64%	3.04%	2.68%	2.77%	1.34%	1.58%	1.44%	1.44%
Elijah Clark State Park 1, 2, & 3	GA	1	316.0	0.64%	0.96%	0.88%	0.71%	0.00%	0.00%	0.00%	0.00%	1.86%	1.97%	2.08%	2.10%	2.40%	2.70%	2.31%	2.61%	1.23%	1.41%	1.32%	1.36%
Holiday Park	GA	1	315.6	0.53%	0.88%	0.73%	0.59%	0.00%	0.00%	0.00%	0.00%	1.59%	1.79%	1.83%	1.91%	1.67%	2.17%	1.98%	2.06%	0.95%	1.22%	1.14%	1.14%
Ft. Gordon Recreation Area 1 & 2	GA	2	315.0	0.33%	0.65%	0.58%	0.46%	0.00%	0.00%	0.00%	0.00%	1.07%	1.43%	1.28%	1.47%	1.06%	1.79%	1.68%	1.59%	0.62%	0.97%	0.89%	0.89%
Plum Branch Yacht Club	SC	1	315.0	0.33%	0.65%	0.58%	0.46%	0.00%	0.00%	0.00%	0.00%	1.07%	1.43%	1.28%	1.47%	1.06%	1.79%	1.68%	1.59%	0.62%	0.97%	0.89%	0.89%
Wildwood Park 1 & 2	GA	2	315.0	0.33%	0.65%	0.58%	0.46%	0.00%	0.00%	0.00%	0.00%	1.07%	1.43%	1.28%	1.47%	1.06%	1.79%	1.68%	1.59%	0.62%	0.97%	0.89%	0.89%

Boat Ramp Name	State	No. of Lanes	Not usable below elevation * (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Bobby Brown State Park 1 & 2	GA	2	315.0	0.33%	0.65%	0.58%	0.46%	0.00%	0.00%	0.00%	0.00%	1.07%	1.43%	1.28%	1.47%	1.06%	1.79%	1.68%	1.59%	0.62%	0.97%	0.89%	0.89%
New Bourdeaux Subdivision Ramp	SC	1	315.0	0.33%	0.65%	0.58%	0.46%	0.00%	0.00%	0.00%	0.00%	1.07%	1.43%	1.28%	1.47%	1.06%	1.79%	1.68%	1.59%	0.62%	0.97%	0.89%	0.89%
Gill Point Ramp	GA	1	314.8	0.32%	0.59%	0.52%	0.36%	0.00%	0.00%	0.00%	0.00%	0.88%	1.31%	0.77%	1.09%	1.06%	1.68%	1.24%	1.30%	0.57%	0.90%	0.63%	0.69%
Cherokee Recreation Area 1	GA	1	314.6	0.29%	0.50%	0.49%	0.33%	0.00%	0.00%	0.00%	0.00%	0.73%	1.12%	0.51%	0.83%	1.04%	1.58%	1.09%	1.10%	0.52%	0.80%	0.52%	0.57%
Little River / Hwy 378	SC	1	314.5	0.29%	0.44%	0.47%	0.32%	0.00%	0.00%	0.00%	0.00%	0.60%	1.01%	0.45%	0.77%	1.04%	1.53%	1.07%	1.06%	0.48%	0.75%	0.50%	0.54%
Parksville Recreation Area	SC	1	314.5	0.29%	0.44%	0.47%	0.32%	0.00%	0.00%	0.00%	0.00%	0.60%	1.01%	0.45%	0.77%	1.04%	1.53%	1.07%	1.06%	0.48%	0.75%	0.50%	0.54%
Buffalo Creek Subdivision Ramp	SC	1	314.5	0.29%	0.44%	0.47%	0.32%	0.00%	0.00%	0.00%	0.00%	0.60%	1.01%	0.45%	0.77%	1.04%	1.53%	1.07%	1.06%	0.48%	0.75%	0.50%	0.54%
Dorn 1, 2, 5, & 6	SC	4	314.4	0.27%	0.36%	0.44%	0.32%	0.00%	0.00%	0.00%	0.00%	0.36%	0.92%	0.37%	0.61%	1.04%	1.49%	1.06%	1.06%	0.42%	0.70%	0.47%	0.50%
Amity Recreation Area 2	GA	1	314.3	0.26%	0.32%	0.39%	0.30%	0.00%	0.00%	0.00%	0.00%	0.25%	0.80%	0.33%	0.46%	1.04%	1.46%	1.06%	1.04%	0.39%	0.65%	0.45%	0.45%
Hamilton Branch State Park (Day Use)	SC	1	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Hamilton Branch State Park 1 & 2	SC	2	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Little River Marina 1	GA	1	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Baker Creek State Park	SC	1	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Tradewinds Marina	GA	1	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Morrahs Ramp 2	GA	1	314.0	0.17%	0.23%	0.33%	0.26%	0.00%	0.00%	0.00%	0.00%	0.07%	0.64%	0.16%	0.16%	1.04%	1.25%	1.04%	1.04%	0.32%	0.53%	0.39%	0.37%
Amity Recreation Area 3	GA	1	313.8	0.02%	0.15%	0.11%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.55%	0.01%	0.03%	0.91%	1.22%	0.98%	1.04%	0.23%	0.48%	0.28%	0.33%
Big Hart Recreation Area	GA	1	313.8	0.02%	0.15%	0.11%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.55%	0.01%	0.03%	0.91%	1.22%	0.98%	1.04%	0.23%	0.48%	0.28%	0.33%
Petersburg Campground	GA	1	313.7	0.00%	0.11%	0.06%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.52%	0.00%	0.01%	0.82%	1.21%	0.92%	0.95%	0.21%	0.46%	0.25%	0.26%
Mt. Carmel Picnic	SC	1	313.7	0.00%	0.11%	0.06%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.52%	0.00%	0.01%	0.82%	1.21%	0.92%	0.95%	0.21%	0.46%	0.25%	0.26%
Modoc Ramp 1	SC	1	313.5	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%	0.70%	1.13%	0.80%	0.82%	0.18%	0.42%	0.20%	0.21%
Clarks Hill Park	GA	1	313.5	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%	0.70%	1.13%	0.80%	0.82%	0.18%	0.42%	0.20%	0.21%
Hawe Creek Campground	SC	1	313.5	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%	0.70%	1.13%	0.80%	0.82%	0.18%	0.42%	0.20%	0.21%

Boat Ramp Name	State	No. of Lanes	Not usable below elevation * (ft AMSL)	Percentage of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Little River Subdivision Ramp	SC	1	313.5	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%	0.70%	1.13%	0.80%	0.82%	0.18%	0.42%	0.20%	0.21%
Mistletoe State Park Low Water Ramp	GA	1	313.5	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.00%	0.70%	1.13%	0.80%	0.82%	0.18%	0.42%	0.20%	0.21%
Hesters Ferry Campground	GA	1	312.9	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.21%	0.00%	0.00%	0.06%	0.95%	0.51%	0.40%	0.02%	0.31%	0.13%	0.10%
Raysville Campground	GA	1	312.2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.12%	0.00%	0.00%	0.00%	0.83%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%
Winfield Campground	GA	1	311.7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Little River Marina 2	GA	1	311.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mt. Carmel Campground	SC	1	311.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Scotts Ferry Ramp	SC	1	310.7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Modoc Shores Subdivision Ramp	SC	1	310.4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Keg Creek Ramp	GA	1	309.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Lake Springs Park 1, 2, & 3	GA	3	308.7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dorn 3 & 4	SC	2	308.4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Leathersville Ramp	GA	1	306.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

* The elevation below which ramps may not be usable for most boats is presented as two feet above the top of the concrete ramp end elevation.

Table 4.3-6 Number of Days Boat Ramps are Unusable on JST Lake (With Future Water Withdrawals and Historic Hydrology) (1939 – 2011)

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Hwy 28 Access Road	SC	1	326.0	1,543	1,544	1,403	1,406	756	772	741	756	1,423	1,397	1,529	1,567	3,313	3,326	3,025	3,048	7,035	7,039	6,698	6,777
Long Cane Creek Ramp	SC	1	325.7	1,226	1,232	1,138	1,149	668	687	659	685	1,210	1,193	1,207	1,244	2,580	2,596	2,441	2,449	5,684	5,708	5,445	5,527
Catfish Ramp	SC	1	325.5	1,060	1,071	1,053	1,070	605	632	608	631	1,074	1,065	1,057	1,092	2,196	2,216	2,145	2,166	4,935	4,984	4,863	4,959
Calhoun Falls Ramp	SC	1	325.0	887	910	935	950	511	517	504	519	920	923	942	946	1,733	1,724	1,790	1,816	4,051	4,074	4,171	4,231
Broad River Campground	GA	1	325.0	887	910	935	950	511	517	504	519	920	923	942	946	1,733	1,724	1,790	1,816	4,051	4,074	4,171	4,231
Cherokee Recreation Area	GA	5	324.7	807	822	852	858	454	458	454	479	888	893	916	915	1,607	1,587	1,665	1,687	3,756	3,760	3,887	3,939
Mistletoe State Park 1 & 2	GA	2	324.2	649	665	711	726	387	373	405	416	831	831	866	869	1,454	1,428	1,516	1,536	3,321	3,297	3,498	3,547
Soap Creek Park	GA	1	324.0	602	609	663	674	373	356	382	392	808	809	843	848	1,396	1,371	1,485	1,505	3,179	3,145	3,373	3,419
Little River Quarry Ramp	SC	1	324.0	602	609	663	674	373	356	382	392	808	809	843	848	1,396	1,371	1,485	1,505	3,179	3,145	3,373	3,419
Lakeside Subdivision Ramp	GA	1	324.0	602	609	663	674	373	356	382	392	808	809	843	848	1,396	1,371	1,485	1,505	3,179	3,145	3,373	3,419
Scotts Ferry (new ramp) 1 & 2	SC	2	323.8	570	573	630	644	348	304	359	366	780	790	822	829	1,346	1,328	1,450	1,475	3,044	2,995	3,261	3,314
Clay Hill Campground	GA	1	323.5	547	549	608	624	288	255	315	323	742	736	778	791	1,258	1,238	1,392	1,429	2,835	2,778	3,093	3,167
Winfield Subdivision	GA	1	323.1	524	520	576	592	236	229	251	260	677	673	708	732	1,149	1,133	1,275	1,342	2,586	2,555	2,810	2,926
Mt Pleasant Ramp	SC	1	322.4	487	487	498	508	203	199	208	210	591	582	616	622	1,043	1,034	1,096	1,131	2,324	2,302	2,418	2,471
Wildwood Park 5 & 6	GA	2	322.0	472	472	482	483	191	178	193	195	542	524	576	586	965	965	1,026	1,034	2,170	2,139	2,277	2,298
Morrahs Ramp	GA	1	321.5	461	457	462	462	165	136	188	187	481	458	509	515	856	854	910	913	1,963	1,905	2,069	2,077
Bussey Point	GA	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Chamberlain Ferry Ramp	GA	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Modoc Campground	SC	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Murray Creek Ramp	GA	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Parkway Ramp	GA	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Cherokee Recreation Area 4	GA	1	321.0	448	444	455	456	126	124	135	143	429	396	457	467	795	771	816	819	1,798	1,735	1,863	1,885
Fishing Creek / Hwy 79 Ramp	GA	1	320.7	426	421	444	445	117	117	127	128	405	365	425	430	770	754	790	791	1,718	1,657	1,786	1,794
Wildwood Park 3 & 4	GA	2	320.0	394	389	404	406	107	96	111	112	349	304	372	380	706	692	744	745	1,556	1,481	1,631	1,643
Maxim Subdivision Ramp	GA	1	320.0	394	389	404	406	107	96	111	112	349	304	372	380	706	692	744	745	1,556	1,481	1,631	1,643
Wells Creek Subdivision	GA	1	320.0	394	389	404	406	107	96	111	112	349	304	372	380	706	692	744	745	1,556	1,481	1,631	1,643
Leroys Ferry Campground	SC	1	319.5	371	347	384	390	66	60	79	88	321	271	342	348	625	603	678	683	1,383	1,281	1,483	1,509
Ridge Road Campground	GA	1	319.0	280	250	312	332	35	34	42	49	287	232	310	324	514	500	548	575	1,116	1,016	1,212	1,280
Cherokee Recreation Area 3	GA	1	318.7	235	228	259	273	30	27	33	36	259	212	283	292	482	476	497	513	1,006	943	1,072	1,114
Chamberlain Ferry Ramp	GA	1	318.3	213	209	223	226	22	21	25	27	223	190	255	264	415	407	453	460	873	827	956	977
Double Branches Ramp	GA	1	318.1	207	206	209	210	19	18	22	24	205	178	233	245	379	375	414	425	810	777	878	904
Soap Creek Marina	GA	1	318.0	205	203	206	207	17	17	20	23	197	175	226	240	363	363	391	408	782	758	843	878
Cherokee Recreation Area 2	GA	1	318.0	205	203	206	207	17	17	20	23	197	175	226	240	363	363	391	408	782	758	843	878
Amity Recreation Area	GA	1	317.9	203	200	204	205	16	16	19	21	191	171	215	229	353	355	378	388	763	742	816	843
Raysville Marina	GA	1	317.6	186	183	194	201	12	12	15	17	177	163	195	202	325	342	347	355	700	700	751	775
Elbert County Subdivision Ramp	GA	1	317.6	186	183	194	201	12	12	15	17	177	163	195	202	325	342	347	355	700	700	751	775
Modoc Ramp 2	SC	1	317.2	155	160	154	160	7	7	10	12	162	152	177	183	288	306	319	326	612	625	660	681
Soap Creek / Hwy 220	GA	1	317.0	141	150	114	122	4	4	8	9	156	150	167	176	272	280	301	312	573	584	590	619

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Ramp																							
Landam Creek Ramp	SC	1	316.2	47	78	59	51	0	0	0	0	133	138	145	146	177	204	180	186	357	420	384	383
Dordon Creek Ramp	SC	1	316.2	47	78	59	51	0	0	0	0	133	138	145	146	177	204	180	186	357	420	384	383
Hickory Knob State Park	SC	1	316.2	47	78	59	51	0	0	0	0	133	138	145	146	177	204	180	186	357	420	384	383
Elijah Clark State Park 1, 2, & 3	GA	1	316.0	42	63	58	47	0	0	0	0	125	132	140	141	161	181	155	175	328	376	353	363
Holiday Park	GA	1	315.6	35	58	48	39	0	0	0	0	107	120	123	128	112	146	133	138	254	324	304	305
Ft. Gordon Recreation Area 1 & 2	GA	2	315.0	22	43	38	30	0	0	0	0	72	96	86	99	71	120	113	107	165	259	237	236
Plum Branch Yacht Club	SC	1	315.0	22	43	38	30	0	0	0	0	72	96	86	99	71	120	113	107	165	259	237	236
Wildwood Park 1 & 2	GA	2	315.0	22	43	38	30	0	0	0	0	72	96	86	99	71	120	113	107	165	259	237	236
Bobby Brown State Park 1 & 2	GA	2	315.0	22	43	38	30	0	0	0	0	72	96	86	99	71	120	113	107	165	259	237	236
New Bourdeaux Subdivision Ramp	SC	1	315.0	22	43	38	30	0	0	0	0	72	96	86	99	71	120	113	107	165	259	237	236
Gill Point Ramp	GA	1	314.8	21	39	34	24	0	0	0	0	59	88	52	73	71	113	83	87	151	240	169	184
Cherokee Recreation Area 1	GA	1	314.6	19	33	32	22	0	0	0	0	49	75	34	56	70	106	73	74	138	214	139	152
Little River / Hwy 378	SC	1	314.5	19	29	31	21	0	0	0	0	40	68	30	52	70	103	72	71	129	200	133	144
Parksville Recreation Area	SC	1	314.5	19	29	31	21	0	0	0	0	40	68	30	52	70	103	72	71	129	200	133	144
Buffalo Creek Subdivision Ramp	SC	1	314.5	19	29	31	21	0	0	0	0	40	68	30	52	70	103	72	71	129	200	133	144
Dorn 1, 2, 5, & 6	SC	4	314.4	18	24	29	21	0	0	0	0	24	62	25	41	70	100	71	71	112	186	125	133
Amity Recreation Area 2	GA	1	314.3	17	21	26	20	0	0	0	0	17	54	22	31	70	98	71	70	104	173	119	121
Hamilton Branch State Park (Day Use)	SC	1	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Hamilton Branch State Park 1 & 2	SC	2	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Little River Marina 1	GA	1	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Baker Creek State Park	SC	1	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Tradewinds Marina	GA	1	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Morrahs Ramp 2	GA	1	314.0	11	15	22	17	0	0	0	0	5	43	11	11	70	84	70	70	86	142	103	98
Amity Recreation Area 3	GA	1	313.8	1	10	7	15	0	0	0	0	0	37	1	2	61	82	66	70	62	129	74	87
Big Hart Recreation Area	GA	1	313.8	1	10	7	15	0	0	0	0	0	37	1	2	61	82	66	70	62	129	74	87
Petersburg Campground	GA	1	313.7	0	7	4	4	0	0	0	0	0	35	0	1	55	81	62	64	55	123	66	69
Mt. Carmel Picnic	SC	1	313.7	0	7	4	4	0	0	0	0	0	35	0	1	55	81	62	64	55	123	66	69
Modoc Ramp 1	SC	1	313.5	0	5	0	0	0	0	0	0	0	32	0	0	47	76	54	55	47	113	54	55
Clarks Hill Park	GA	1	313.5	0	5	0	0	0	0	0	0	0	32	0	0	47	76	54	55	47	113	54	55
Hawe Creek Campground	SC	1	313.5	0	5	0	0	0	0	0	0	0	32	0	0	47	76	54	55	47	113	54	55
Little River Subdivision Ramp	SC	1	313.5	0	5	0	0	0	0	0	0	0	32	0	0	47	76	54	55	47	113	54	55
Mistletoe State Park Low Water Ramp	GA	1	313.5	0	5	0	0	0	0	0	0	0	32	0	0	47	76	54	55	47	113	54	55
Hesters Ferry Campground	GA	1	312.9	0	4	0	0	0	0	0	0	0	14	0	0	4	64	34	27	4	82	34	27
Raysville Campground	GA	1	312.2	0	0	0	0	0	0	0	0	0	8	0	0	0	56	0	0	0	64	0	0
Winfield Campground	GA	1	311.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Boat Ramp Name	State	No. of Lanes	Not usable below elevation* (ft AMSL)	Number of days when ramp is not usable																			
				Jan - Mar (6,588 days)				Apr - Jun (6,643 days)				Jul - Sep (6,716 days)				Oct - Dec (6,715 days)				Total POR (26,662 days)			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Little River Marina 2	GA	1	311.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mt. Carmel Campground	SC	1	311.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scotts Ferry Ramp	SC	1	310.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modoc Shores Subdivision Ramp	SC	1	310.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Keg Creek Ramp	GA	1	309.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Springs Park 1, 2, & 3	GA	3	308.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorn 3 & 4	SC	2	308.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leathersville Ramp	GA	1	306.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* The elevation below which ramps may not be usable for most boats is presented as two feet above the top of the concrete ramp end elevation.

Using climate change hydrology instead of historic hydrology results in more unusable ramp days at both Hartwell and JST Lakes. Differences between both the seasonal results and annual results mirror those of the future water withdrawals with historic hydrology model runs. See Tables N-9 through N-12 in Appendix N for detailed results for Hartwell Lake and JST Lake, respectively.

4.3.2 *Lower Savannah River Basin Public Boat-Launching Ramps*

There are approximately fifty-five known public boat ramps with various owners in the Lower Savannah River Basin. No information was available regarding the usability of the boat ramps at various river flows. However, since USACE would continue to discharge from JST Dam under the conditions of the 2012 Drought Plan under all of the alternatives, no changes would occur in the daily volume of flow released from JST. Therefore, no impacts to boat ramps in the Lower Savannah River Basin are expected from any alternative.

4.3.3 *Swimming*

There are no specific criteria for public swimming areas to be closed due to reservoir elevations on the Duke Energy reservoirs. Therefore, none of the operating scenarios are expected to impact swimming access at the Duke Energy facilities. When reservoir levels at Hartwell Lake drop to 657 feet AMSL, the swimming areas become less desirable (USACE 2008a), and at reservoir elevations of 654 feet AMSL and lower, all designated swimming areas are dry. Hartwell Lake drops below 657 feet AMSL annually and below 654 feet AMSL during most moderate and extreme droughts (Figure 3.5-1). There are only minor differences in the frequency and duration of such occurrences between the alternatives. At JST Lake, when elevations drop to 327 feet AMSL, the swimming areas become less desirable (USACE 2008a). When reservoir elevations drop to 324 feet AMSL, all designated swimming areas are dry (USACE 2008a). Like Hartwell Lake, swimming areas at JST have occurrences of limited access. However, only during moderate and extreme droughts (i.e., 1955-1956, 1982, 1987-1989, 2000-2003, and 2007-2009) do the swimming areas become completely dry (Figure 3.5-3). There are only minor differences in swimming access in JST Lake between the modeling alternatives.

4.3.4 *Mitigation for Impacts to Recreation*

The proposed alternatives would modify water levels in the Duke and USACE reservoirs during droughts, altering the availability of some boat ramps to recreational users. The following table shows the effects of the proposed alternatives on users of the boat ramps around the Duke Energy projects:

Table 4.4-7 Number of Days Boat Ramps Are Not Available

DUKE ENERGY PROJECT	ALTERNATIVES			
	NAA / A1	**A2**	**A3**	**A4**
Jocassee	1	0	0	0
Keowee	2,225	0	36	79
Total	2,226	0	36	79

Notes: (1) Number of days in the 26,662 day (73-year) period of record.
(2) These numbers include only boat ramps that are operated by Duke Energy

The boat ramps on the Duke Energy projects would be available more days with each of the proposed alternatives. No mitigation is needed for this beneficial effect.

Previous Corps documents reveal the following level of visitors at the USACE projects and those that use the recreation areas:

Table 4.3-8 Visitation at USACE Reservoirs

USACE PROJECT	TOTAL ANNUAL VISITATION	VISITATION TO RECREATION AREAS
Hartwell	10,085,193	2,318,568
Richard B. Russell	999,866	917,125
J. Strom Thurmond	5,692,851	1,950,967

Note: 10-year average from 2003-2012

In general, the alternatives would reduce pool levels in the USACE reservoirs and the availability of some boat ramps, leading to lower access to the water and a loss in recreational use of the reservoirs. Pool levels at RBR would not be noticeably affected by any of the alternatives, so no impacts to recreational users are expected at that project. For the Hartwell and JST Projects, USACE evaluated the value of the lost access and use by following the USACE Economic Guidance Memorandum, 14-03, Unit Day Values for Recreation for Fiscal Year 2014. Through procedures included in that document, unit day values can be developed for an average day of recreational use on the two USACE reservoirs. That value can then be multiplied by the number of days an alternative would impact users to produce an economic value for the lost recreational access and use. Savannah District used the following assumptions in its development of unit day values for recreational use on the Hartwell and JST reservoirs:

- Considered General Recreation
- Recreational experience
    - Several general activities; one high quality value activity
    - 16 points (out of 30 points)
- Availability of opportunity
    - Several within 1 hour travel time; a few within 30 minutes travel time
    - 3 points (out of 18 points)
- Carrying capacity
    - Optimum facilities to conduct activity at site
    - 11 points (out of 14 points)
- Accessibility
    - Good access, high standard road to site; good access within site
    - 18 points (out of 18 points)
- Environmental quality
    - High aesthetic quality; no factors exist that lower quality
    - 15 points (out of 20 points)

Appendix V contains the full USACE Economic Guidance Memorandum, 14-03, Unit Day Values for Recreation for Fiscal Year 2014. That document describes how points should be assigned and the criteria for assigning different values. Using the points described above, Savannah District believes the recreational value for use of the Hartwell and JST reservoirs has a total of 63 points. Using the information below from USACE Economic Guidance Memorandum 14-03, the economic value of that use would be $8.89 per day.

Table 4.3-9 Conversion of Points to Dollar Values

Point Values	General Recreation Values (1)	General Fishing and Hunting Values (1)	Specialized Fishing and Hunting Values (2)	Specialized Recreation Values other than Fishing and Hunting (2)
0	$ 3.84	$ 5.52	$ 26.90	$ 15.61
10	$ 4.56	$ 6.24	$ 27.62	$ 16.57
20	$ 5.04	$ 6.72	$ 28.10	$ 17.77
30	$ 5.76	$ 7.44	$ 28.82	$ 19.21
40	$ 7.20	$ 8.17	$ 29.54	$ 20.41
50	$ 8.17	$ 8.89	$ 32.42	$ 23.05
60	$ 8.89	$ 9.85	$ 35.30	$ 25.46
70	$ 9.37	$ 10.33	$ 37.46	$ 30.74
80	$ 10.33	$ 11.05	$ 40.35	$ 35.78
90	$ 11.05	$ 11.29	$ 43.23	$ 40.83
100	$ 11.53	$ 11.53	$ 45.63	$ 45.63

Based on a unit day value of $8.89 per day for recreation users of the USACE reservoirs, the effects of the alternatives on recreation are calculated as shown in the following two pages and summarized in Table 4.3-10.

J. Strom Thurmond

Boat Ramp Name	State	No. of Lanes	Not useable below elevation (ft AMSL)	Number of days when ramp is not useable					Percent of time that lane not available				Years	Number of days in 50 Years that Lanes not Available				Visitors per year	Total Revenue Lost				if positive, the location lost less than the NAA			
				Oct - Dec (6,715 days)	Total POR (26,662 days)								50										Delta Total Revenue Lost			
				A4	NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	days	NAA/A1	A2	A3	A4		NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Amity Recreation Area 3	GA	1	313.8	70	62	129	74	87	0.2%	0.5%	0.3%	0.3%	18250	42	88	51	60	49860.8	$ 51,538	$ 107,233	$ 61,513	$ 72,320	$ -	$ (55,695)	$ (9,975)	$ (20,782)
Baker Creek State Park	SC	1	314.0	70	86	142	103	98	0.3%	0.5%	0.4%	0.4%	18250	59	97	71	67	32269.7	$ 46,267	$ 76,395	$ 55,413	$ 52,723	$ -	$ (30,127)	$ (9,146)	$ (6,456)
Big Hart Recreation Area	GA	1	313.8	70	62	129	74	87	0.2%	0.5%	0.3%	0.3%	18250	42	88	51	60	34182.8	$ 35,333	$ 73,515	$ 42,171	$ 49,580	$ -	$ (38,182)	$ (6,839)	$ (14,247)
Bobby Brown State Park 1 & 2	GA	2	315.0	107	165	259	237	236	0.6%	1.0%	0.9%	0.9%	18250	113	177	162	162	32719.7	$ 90,006	$ 141,282	$ 129,282	$ 128,736	$ -	$ (51,276)	$ (39,275)	$ (38,730)
Broad River Campground	GA	1	325.0	1,816	4051	4074	4171	4231	15.2%	15.3%	15.6%	15.9%	18250	2773	2789	2855	2896	8416.3	$ 568,411	$ 571,638	$ 585,249	$ 593,667	$ -	$ (3,227)	$ (16,838)	$ (25,256)
Buffalo Creek Subdivision Ramp	SC	1	314.5	71	129	200	133	144	0.5%	0.8%	0.5%	0.5%	18250	88	137	91	99	400	$ 860	$ 1,334	$ 887	$ 960	$ -	$ (473)	$ (27)	$ (100)
Bussey Point	GA	1	321.0	819	1798	1735	1863	1885	6.7%	6.5%	7.0%	7.1%	18250	1231	1188	1275	1290	10748	$ 322,178	$ 310,890	$ 333,826	$ 337,768	$ -	$ 11,289	$ (11,647)	$ (15,589)
Calhoun Falls Ramp	SC	1	325.0	1,816	4051	4074	4171	4231	15.2%	15.3%	15.6%	15.9%	18250	2773	2789	2855	2896	13515.3	$ 912,782	$ 917,964	$ 939,821	$ 953,340	$ -	$ (5,182)	$ (27,039)	$ (40,558)
Catfish Ramp	SC	1	325.5	2,166	4935	4984	4863	4959	18.5%	18.7%	18.2%	18.6%	18250	3378	3412	3329	3394	300	$ 24,682	$ 24,927	$ 24,322	$ 24,802	$ -	$ (245)	$ 360	$ (120)
Chamberlain Ferry Ramp	GA	1	318.3	460	873	827	956	977	3.3%	3.1%	3.6%	3.7%	18250	598	566	654	669	25171.2	$ 366,351	$ 347,047	$ 401,181	$ 409,994	$ -	$ 19,304	$ (34,831)	$ (43,643)
Cherokee Recreation Area 1	GA	1	314.6	74	138	214	139	152	0.5%	0.8%	0.5%	0.6%	18250	94	146	95	104	87385.3	$ 201,046	$ 311,768	$ 202,503	$ 221,443	$ -	$ (110,721)	$ (1,457)	$ (20,396)
Clarks Hill Park	GA	1	313.5	55	47	113	54	55	0.2%	0.4%	0.2%	0.2%	18250	32	77	37	38	53296.5	$ 41,761	$ 100,405	$ 47,981	$ 48,870	$ -	$ (58,644)	$ (6,220)	$ (7,108)
Clay Hill Campground	GA	1	323.5	1,429	2835	2778	3093	3167	10.6%	10.4%	11.6%	11.9%	18250	1941	1902	2117	2168	6691.8	$ 316,282	$ 309,923	$ 345,066	$ 353,321	$ -	$ 6,359	$ (28,783)	$ (37,039)
Dordon Creek Ramp	SC	1	316.2	186	357	420	384	383	1.3%	1.6%	1.4%	1.4%	18250	244	287	263	262	17627.6	$ 104,916	$ 123,430	$ 112,850	$ 112,557	$ -	$ (18,515)	$ (7,935)	$ (7,641)
Dorn 3 & 4	SC	2	308.4	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	5708.6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Double Branches Ramp	GA	1	318.1	425	810	777	878	904	3.0%	2.9%	3.3%	3.4%	18250	554	532	601	619	13445.3	$ 181,566	$ 174,169	$ 196,809	$ 202,637	$ -	$ 7,397	$ (15,243)	$ (21,071)
Elbert County Subdivision Ramp	GA	1	317.6	355	700	700	751	775	2.6%	2.6%	2.8%	2.9%	18250	479	479	514	530	200	$ 2,334	$ 2,334	$ 2,504	$ 2,584	$ -	$ -	$ (170)	$ (250)
Elijah Clark State Park 1, 2, & 3	GA	1	316.0	175	328	376	353	363	1.2%	1.4%	1.3%	1.4%	18250	225	257	242	248	81314.9	$ 444,655	$ 509,726	$ 478,546	$ 492,103	$ -	$ (65,071)	$ (33,891)	$ (47,448)
Fishing Creek / Hwy 79 Ramp	GA	1	320.7	791	1718	1657	1786	1794	6.4%	6.2%	6.7%	6.7%	18250	1176	1134	1223	1228	1000	$ 28,642	$ 27,625	$ 29,776	$ 29,909	$ -	$ 1,017	$ (1,134)	$ (1,267)
Ft. Gordon Recreation Area 1 & 2	GA	2	315.0	107	165	259	237	236	0.6%	1.0%	0.9%	0.9%	18250	113	177	162	162	81069.3	$ 223,007	$ 350,054	$ 320,320	$ 318,968	$ -	$ (127,047)	$ (97,312)	$ (95,961)
Gill Point Ramp	GA	1	314.8	87	151	240	169	184	0.6%	0.9%	0.6%	0.7%	18250	103	164	116	126	33428.9	$ 84,155	$ 133,756	$ 94,186	$ 102,546	$ -	$ (49,601)	$ (10,032)	$ (18,391)
Hamilton Branch State Park (Day Use)	SC	1	314.0	70	86	142	103	98	0.3%	0.5%	0.4%	0.4%	18250	59	97	71	67	56020	$ 80,319	$ 132,620	$ 96,197	$ 91,527	$ -	$ (52,301)	$ (15,877)	$ (11,207)
Hamilton Branch State Park 1 & 2	SC	2	314.0	70	86	142	103	98	0.3%	0.5%	0.4%	0.4%	18250	59	97	71	67	7743.3	$ 11,102	$ 18,331	$ 13,297	$ 12,651	$ -	$ (7,229)	$ (2,195)	$ (1,549)
Hawe Creek Campground	SC	1	313.5	55	47	113	54	55	0.2%	0.4%	0.2%	0.2%	18250	32	77	37	38	3632.2	$ 2,846	$ 6,843	$ 3,270	$ 3,331	$ -	$ (3,997)	$ (424)	$ (484)
Hesters Ferry Campground	GA	1	312.9	27	4	82	34	27	0.0%	0.3%	0.1%	0.1%	18250	3	56	23	18	3632	$ 242	$ 4,965	$ 2,059	$ 1,635	$ -	$ (4,723)	$ (1,817)	$ (1,393)
Hickory Knob State Park	SC	1	316.2	186	357	420	384	383	1.3%	1.6%	1.4%	1.4%	18250	244	287	263	262	103396.1	$ 615,391	$ 723,990	$ 661,934	$ 660,210	$ -	$ (108,598)	$ (46,542)	$ (44,818)
Holiday Park	GA	1	315.6	138	254	324	304	305	1.0%	1.2%	1.1%	1.1%	18250	174	222	208	209	14687.6	$ 62,196	$ 79,337	$ 74,440	$ 74,684	$ -	$ (17,141)	$ (12,243)	$ (12,488)
Hwy 28 Access Road	SC	1	326.0	3,048	7035	7039	6698	6777	26.4%	26.4%	25.1%	25.4%	18250	4815	4818	4585	4639	400	$ 46,914	$ 46,941	$ 44,667	$ 45,194	$ -	$ (27)	$ 2,247	$ 1,721
Keg Creek Ramp	GA	1	309.0	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	30076.8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Lake Springs Park 1, 2, & 3	GA	3	308.7	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	174425.8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lakeside Subdivision Ramp	GA	1	324.0	1,505	3179	3145	3373	3419	11.9%	11.8%	12.7%	12.8%	18250	2176	2153	2309	2340	500	$ 26,500	$ 26,216	$ 28,117	$ 28,500	$ -	$ 283	$ (1,617)	$ (2,001)
Landam Creek Ramp	SC	1	316.2	186	357	420	384	383	1.3%	1.6%	1.4%	1.4%	18250	244	287	263	262	6571.3	$ 39,111	$ 46,013	$ 42,069	$ 41,959	$ -	$ (6,902)	$ (2,958)	$ (2,848)
Leathersville Ramp	GA	1	306.3	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	10524.7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Leroys Ferry Campground	SC	1	319.5	683	1383	1281	1483	1509	5.2%	4.8%	5.6%	5.7%	18250	947	877	1015	1033	5774.5	$ 133,142	$ 123,323	$ 142,769	$ 145,272	$ -	$ 9,820	$ (9,627)	$ (12,130)
Little River / Hwy 378	SC	1	314.5	71	129	200	133	144	0.5%	0.8%	0.5%	0.5%	18250	88	137	91	99	20056.1	$ 43,134	$ 66,874	$ 44,471	$ 48,149	$ -	$ (23,740)	$ (1,337)	$ (5,016)
Little River Marina 2	GA	1	311.3	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	24661.8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Little River Quarry Ramp	SC	1	324.0	1,505	3179	3145	3373	3419	11.9%	11.8%	12.7%	12.8%	18250	2176	2153	2309	2340	400	$ 21,200	$ 20,973	$ 22,493	$ 22,800	$ -	$ 227	$ (1,294)	$ (1,600)
Little River Subdivision Ramp	SC	1	313.5	55	47	113	54	55	0.2%	0.4%	0.2%	0.2%	18250	32	77	37	38	400	$ 313	$ 754	$ 360	$ 367	$ -	$ (440)	$ (47)	$ (53)
Long Cane Creek Ramp	SC	1	325.7	2,449	5684	5708	5445	5527	21.3%	21.4%	20.4%	20.7%	18250	3891	3907	3727	3783	500	$ 47,381	$ 47,581	$ 45,389	$ 46,072	$ -	$ (200)	$ 1,992	$ 1,309
Maxim Subdivision Ramp	GA	1	320.0	745	1556	1481	1631	1643	5.8%	5.6%	6.1%	6.2%	18250	1065	1014	1116	1125	200	$ 5,188	$ 4,938	$ 5,438	$ 5,478	$ -	$ 250	$ (250)	$ (290)
Mistletoe State Park Low Water Ramp	GA	1	313.5	55	47	113	54	55	0.2%	0.4%	0.2%	0.2%	18250	32	77	37	38	73833	$ 57,853	$ 139,094	$ 66,470	$ 67,701	$ -	$ (81,241)	$ (8,616)	$ (9,847)
Modoc Campground	SC	1	321.0	819	1798	1735	1863	1885	6.7%	6.5%	7.0%	7.1%	18250	1231	1188	1275	1290	20810	$ 623,793	$ 601,936	$ 646,344	$ 653,977	$ -	$ 21,857	$ (22,551)	$ (30,184)
Modoc Ramp 1	SC	1	313.5	55	47	113	54	55	0.2%	0.4%	0.2%	0.2%	18250	32	77	37	38	25782.7	$ 20,203	$ 48,572	$ 23,211	$ 23,641	$ -	$ (28,369)	$ (3,009)	$ (3,439)
Modoc Shores Subdivision Ramp	SC	1	310.4	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Morrahs Ramp 2	GA	1	314.0	70	86	142	103	98	0.3%	0.5%	0.4%	0.4%	18250	59	97	71	67	19861.8	$ 28,477	$ 47,020	$ 34,106	$ 32,451	$ -	$ (18,543)	$ (5,629)	$ (3,974)
Mt Pleasant Ramp	SC	1	322.4	1,131	2324	2302	2418	2471	8.7%	8.6%	9.1%	9.3%	18250	1591	1576	1655	1691	4000	$ 154,980	$ 153,513	$ 161,248	$ 164,783	$ -	$ 1,467	$ (6,269)	$ (9,803)
Mt. Carmel Campground	SC	1	311.0	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	14383.4	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Mt. Carmel Picnic	SC	1	313.7	64	55	123	66	69	0.2%	0.5%	0.2%	0.3%	18250	38	84	45	47	14383.4	$ 13,189	$ 29,495	$ 15,826	$ 16,546	$ -	$ (16,306)	$ (2,638)	$ (3,357)
Murray Creek Ramp	GA	1	321.0	819	1798	1735	1863	1885	6.7%	6.5%	7.0%	7.1%	18250	1231	1188	1275	1290	10323.3	$ 309,448	$ 298,605	$ 320,635	$ 324,421	$ -	$ 10,843	$ (11,187)	$ (14,973)
New Bourdeaux Subdivision Ramp	SC	1	315.0	107	165	259	237	236	0.6%	1.0%	0.9%	0.9%	18250	113	177	162	162	300	$ 825	$ 1,295	$ 1,185	$ 1,180	$ -	$ (470)	$ (360)	$ 355)
Parksville Recreation Area	SC	1	314.5	71	129	200	133	144	0.5%	0.8%	0.5%	0.5%	18250	88	137	91	99	45266.7	$ 97,353	$ 150,934	$ 100,371	$ 108,673	$ -	$ (53,582)	$ (3,019)	$ (11,320)
Parkway Ramp	GA	1	321.0	819	1798	1735	1863	1885	6.7%	6.5%	7.0%	7.1%	18250	1231	1188	1275	1290	300	$ 8,993	$ 8,678	$ 9,318	$ 9,428	$ -	$ 315	$ (325)	$ (435)
Petersburg Campground	GA	1	313.7	64	55	123	66	69	0.2%	0.5%	0.2%	0.3%	18250	38	84	45	47	74966.1	$ 68,740	$ 153,727	$ 82,487	$ 86,237	$ -	$ (84,987)	$ (13,748)	$ (17,497)
Plum Branch Yacht Club	SC	1	315.0	107	165	259	237	236	0.6%	1.0%	0.9%	0.9%	18250	113	177	162	162	41255	$ 113,485	$ 178,138	$ 163,006	$ 162,318	$ -	$ (64,652)	$ (49,521)	$ (48,833)
Raysville Campground	GA	1	312.2	0	0	64	0	0	0.0%	0.2%	0.0%	0.0%	18250	0	44	0	0	19676.7	$ -	$ 20,995	$ -	$ -	$ -	$ (20,995)	$ -	$ -
Raysville Marina	GA	1	317.6	355	700	700	751	775	2.6%	2.6%	2.8%	2.9%	18250	479	479	514	530	34653	$ 404,406	$ 404,406	$ 433,870	$ 447,736	$ -	$ -	$ (29,464)	$ (43,329)
Ridge Road Campground	GA	1	319.0	575	1116	1016	1212	1280	4.2%	3.8%	4.5%	4.8%	18250	764	695	830	876	19453.2	$ 361,938	$ 329,506	$ 393,073	$ 415,126	$ -	$ 32,432	$ (31,134)	$ (53,188)
Scotts Ferry Ramp	SC	1	310.7	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	35150.4	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Soap Creek / Hwy 220 Ramp	GA	1	317.0	312	573	584	590	619	2.1%	2.2%	2.2%	2.3%	18250	392	400	404	424	1500	$ 14,329	$ 14,604	$ 14,754	$ 15,480	$ -	$ (275)	$ (425)	$ (1,150)
Soap Creek Marina	GA	1	318.0	408	782	758	843	878	2.9%	2.8%	3.2%	3.3%	18250	535	519	577	601	63317.6	$ 825,487	$ 800,152	$ 889,879	$ 926,826	$ -	$ 25,335	$ (64,392	$ (101,339)
Soap Creek Park	GA	1	324.0	1,505	3179	3145	3373	3419	11.9%	11.8%	12.7%	12.8%	18250	2176	2153	2309	2340	400	$ 21,200	$ 20,973	$ 22,493	$ 22,800	$ -	$ 227	$ (1,294)	$ (1,600)
Tradewinds Marina	GA	1	314.0	70	86	142	103	98	0.3%	0.5%	0.4%	0.4%	18250	59	97	71	67	89186.9	$ 127,873	$ 211,139	$ 153,150	$ 145,716	$ -	$ (83,266)	$ (25,277)	$ (17,843)
Wells Creek Subdivision	GA	1	320.0	745	1556	1481	1631	1643	5.8%	5.6%	6.1%	6.2%	18250	1065	1014	1116	1125	300	$ 7,782	$ 7,407	$ 8,157	$ 8,217	$ -	$ 375	$ (375)	$ (435)
Wildwood Park 1 & 2	GA	2	315.0	107	165	259	237	236	0.6%	1.0%	0.9%	0.9%	18250	113	177	162	162	78183.2	$ 215,068	$ 337,592	$ 308,916	$ 307,613	$ -	$ (122,524)	$ (93,848)	$ (92,545)
Winfield Campground	GA	1	311.7	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	18250	0	0	0	0	34347.8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Winfield Subdivision	GA	1	323.1	1,342	2586	2555	2810	2926	9.7%	9.6%	10.5%	11.0%	18250	1770	1749	1923	2003	700	$ 30,179	$ 29,817	$ 32,793	$ 34,147	$ -	$ 362	$ (2,614)	$ (3,968)

Hartwell

Boat Ramp Name	State	No. of Lanes	Not useable below elevation (ft AMSL)	Number of days when ramp is not useable Total POR (26,662 days)				Percent of time that lane not available				Years 50	Number of days in 50 Years that Lanes not Available				Visitors / year	Total Revenue Lost				Delta Total Revenue Lost			
				NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4	days	NAA/A1	A2	A3	A4		NAA/A1	A2	A3	A4	NAA/A1	A2	A3	A4
Apple Island	SC	1	651.5	2092	1936	2329	2331	7.8%	7.3%	8.7%	8.7%	18250	1432	1325	1594	1596	13032	$ 454,519	$ 420,625	$ 506,011	$ 506,445	$ -	$ 33,893	$ (51,492)	$ (51,926)
Asbury (camping)	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	22953	$ 86,865	$ 56,634	$ 91,074	$ 91,840	$ -	$ 30,231	$ (4,209)	$ (4,975)
Barton Mill	SC	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	4811	$ 250,648	$ 244,873	$ 287,864	$ 287,704	$ -	$ 5,775	$ (37,216)	$ (37,056)
Big Oaks (right lane)	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	125793	$ 501,226	$ 371,201	$ 538,975	$ 559,947	$ -	$ 130,025	$ (37,749)	$ (58,721)
Big Water	SC	1	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	16375	$ 33,579	$ 11,739	$ 34,671	$ 42,588	$ -	$ 21,840	$ (1,092)	$ (9,009)
Bradberry	GA	1	655.0	5685	5668	6332	6383	21.3%	21.3%	23.7%	23.9%	18250	3891	3880	4334	4369	16313	$ 1,546,121	$ 1,541,497	$ 1,722,082	$ 1,735,952	$ -	$ 4,623	$ (175,961)	$ (189,832)
Brown Road	SC	1	657.0	10332	10289	10868	10909	38.8%	38.6%	40.8%	40.9%	18250	7072	7043	7439	7467	29696	$ 5,115,186	$ 5,093,897	$ 5,380,549	$ 5,400,848	$ -	$ 21,289	$ (265,364)	$ (285,662)
Broyles (middle ramp)	SC	1	642.0	205	133	222	225	0.8%	0.5%	0.8%	0.8%	18250	140	91	152	154	43070	$ 147,200	$ 95,500	$ 159,407	$ 161,561	$ -	$ 51,700	$ (12,207)	$ (14,361)
Bruce Creek	GA	1	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	15331	$ 31,438	$ 10,991	$ 32,460	$ 39,873	$ -	$ 20,447	$ (1,022)	$ (8,435)
Camp Creek	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	11062	$ 44,078	$ 32,643	$ 47,397	$ 49,242	$ -	$ 11,434	$ (3,320)	$ (5,164)
Carters Ferry	GA	1	645.0	285	243	384	395	1.1%	0.9%	1.4%	1.5%	18250	195	166	263	270	8219	$ 39,052	$ 33,297	$ 52,617	$ 54,125	$ -	$ 5,755	$ (13,565)	$ (15,073)
Choestoea	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	13484	$ 53,727	$ 39,789	$ 57,773	$ 60,021	$ -	$ 13,938	$ (4,046)	$ (6,294)
Clemson Marina	SC	1	645.5	340	287	478	481	1.3%	1.1%	1.8%	1.8%	18250	233	196	327	329	35103	$ 198,979	$ 167,962	$ 279,741	$ 281,497	$ -	$ 31,017	$ (80,762)	$ (82,518)
Cleveland	GA	1	649.5	1505	1250	1624	1657	5.6%	4.7%	6.1%	6.2%	18250	1030	856	1112	1134	13027	$ 326,854	$ 271,473	$ 352,698	$ 359,865	$ -	$ 55,381	$ (25,844)	$ (33,011)
Coneross	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	13610	$ 54,231	$ 40,163	$ 58,315	$ 60,584	$ -	$ 14,068	$ (4,084)	$ (6,353)
Cove Inlet	SC	1	656.5	8923	8910	9520	9569	33.5%	33.4%	35.7%	35.9%	18250	6108	6099	6516	6550	4811	$ 715,691	$ 714,648	$ 763,574	$ 767,505	$ -	$ 1,043	$ (47,884)	$ (51,814)
Crawford Ferry	GA	1	643.3	228	161	240	241	0.9%	0.6%	0.9%	0.9%	18250	156	110	164	165	11286	$ 42,898	$ 30,292	$ 45,156	$ 45,344	$ -	$ 12,606	$ (2,258)	$ (2,446)
Darvin Wright City Park	SC	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	103920	$ 5,414,119	$ 5,289,378	$ 6,218,007	$ 6,214,542	$ -	$ 124,741	$ (803,888)	$ (800,423)
Denver	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	21873	$ 82,778	$ 53,970	$ 86,789	$ 87,518	$ -	$ 28,808	$ (4,011)	$ (4,741)
Double Spring	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	12423	$ 49,500	$ 36,659	$ 53,228	$ 55,299	$ -	$ 12,841	$ (3,728)	$ (5,799)
Duncan Branch	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	11063	$ 44,080	$ 32,645	$ 47,399	$ 49,244	$ -	$ 11,435	$ (3,320)	$ (5,164)
Durham	SC	1	655.7	6452	6437	7136	7165	24.2%	24.1%	26.8%	26.9%	18250	4416	4406	4885	4904	10854	$ 1,167,506	$ 1,164,792	$ 1,291,278	$ 1,296,525	$ -	$ 2,714	$ (123,772)	$ (129,019)
Eighteen Mile Creek	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	18243	$ 69,041	$ 45,013	$ 72,386	$ 72,995	$ -	$ 24,027	$ (3,346)	$ (3,954)
Elrod Ferry	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	35726	$ 135,204	$ 88,150	$ 141,755	$ 142,946	$ -	$ 47,053	$ (6,552)	$ (7,743)
Fairplay (right lane)	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	32403	$ 129,111	$ 95,618	$ 138,834	$ 144,237	$ -	$ 33,493	$ (9,724)	$ (15,126)
Friendship (right lane)	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	46169	$ 183,960	$ 136,238	$ 197,815	$ 205,512	$ -	$ 47,722	$ (13,855)	$ (21,552)
Glenn Ferry	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	11282	$ 44,955	$ 33,293	$ 48,340	$ 50,221	$ -	$ 11,662	$ (3,386)	$ (5,267)
Green Pond	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	27935	$ 111,309	$ 82,434	$ 119,692	$ 124,349	$ -	$ 28,875	$ (8,383)	$ (13,040)
Gum Branch	GA	6	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	13189	$ 52,552	$ 38,919	$ 56,509	$ 58,708	$ -	$ 13,633	$ (3,958)	$ (6,157)
Harbor Light Marina	GA	2	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	46787	$ 177,063	$ 115,442	$ 185,643	$ 187,203	$ -	$ 61,621	$ (8,580)	$ (10,140)

Hart State Park	GA	2	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	56238	$ 212,831	$ 138,762	$ 223,144	$ 225,019	$ -	$ 74,069	$ (10,313)	$ (12,189)
Hartwell Marina	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	43906	$ 166,162	$ 108,334	$ 174,214	$ 175,677	$ -	$ 57,827	$ (8,052)	$ (9,516)
Hatton's Ford	SC	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	27545	$ 109,753	$ 81,281	$ 118,019	$ 122,611	$ -	$ 28,471	$ (8,266)	$ (12,858)
Holcomb	GA	1	650.0	1679	1462	1794	1825	6.3%	5.5%	6.7%	6.8%	18250	1149	1001	1228	1249	15459	$ 432,716	$ 376,790	$ 462,354	$ 470,343	$ -	$ 55,926	$ (29,638)	$ (37,627)
Holder’s Access	SC	1	658.0	13839	13813	14104	14157	51.9%	51.8%	52.9%	53.1%	18250	9473	9455	9654	9690	4811	$ 1,109,990	$ 1,107,905	$ 1,131,245	$ 1,135,496	$ -	$ 2,085	$ (21,255)	$ (25,506)
Honea Path	SC	1	648.5	1035	898	1270	1295	3.9%	3.4%	4.8%	4.9%	18250	708	615	869	886	16060	$ 277,115	$ 240,434	$ 340,034	$ 346,728	$ -	$ 36,681	$ (62,920)	$ (69,613)
Hurricane Creek	SC	1	657.0	10332	10289	10868	10909	38.8%	38.6%	40.8%	40.9%	18250	7072	7043	7439	7467	37031	$ 6,378,565	$ 6,352,019	$ 6,709,470	$ 6,734,782	$ -	$ 26,546	$ (330,905)	$ (356,217)
Jack’s Landing	SC	1	658.0	13839	13813	14104	14157	51.9%	51.8%	52.9%	53.1%	18250	9473	9455	9654	9690	20901	$ 4,822,331	$ 4,813,271	$ 4,914,673	$ 4,933,141	$ -	$ 9,060	$ (92,342)	$ (110,810)
Jarrett	SC	1	650.0	1679	1462	1794	1825	6.3%	5.5%	6.7%	6.8%	18250	1149	1001	1228	1249	11024	$ 308,572	$ 268,691	$ 329,708	$ 335,405	$ -	$ 39,881	$ (21,135)	$ (26,832)
Jenkins Ferry	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	14635	$ 55,387	$ 36,111	$ 58,071	$ 58,559	$ -	$ 19,276	$ (2,684)	$ (3,172)
Lake Hartwell State Park	SC	2	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	38365	$ 78,672	$ 27,503	$ 81,230	$ 99,779	$ -	$ 51,169	$ (2,558)	$ (21,107)
Lakeshore	SC	1	658.0	13839	13813	14104	14157	51.9%	51.8%	52.9%	53.1%	18250	9473	9455	9654	9690	6455	$ 1,489,316	$ 1,486,518	$ 1,517,834	$ 1,523,538	$ -	$ 2,798	$ (28,519)	$ (34,222)
Lawrence Bridge	SC	1	651.0	1946	1762	2111	2123	7.3%	6.6%	7.9%	8.0%	18250	1332	1206	1445	1453	16795	$ 544,878	$ 493,358	$ 591,078	$ 594,438	$ -	$ 51,520	$ (46,200)	$ (49,560)
Lightwood Log Creek	GA	1	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	16313	$ 33,453	$ 11,695	$ 34,540	$ 42,428	$ -	$ 21,758	$ (1,088)	$ (8,975)
Long Point	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	37949	$ 151,208	$ 111,982	$ 162,596	$ 168,922	$ -	$ 39,225	$ (11,388)	$ (17,715)
Martin Creek	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	16062	$ 60,788	$ 39,632	$ 63,733	$ 64,269	$ -	$ 21,155	$ (2,946)	$ (3,481)
Mary Ann Branch	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	8854	$ 33,507	$ 21,846	$ 35,130	$ 35,425	$ -	$ 11,661	$ (1,624)	$ (1,919)
Milltown	GA	1	645.4	325	279	452	461	1.2%	1.0%	1.7%	1.7%	18250	222	191	309	316	3981	$ 21,570	$ 18,517	$ 29,999	$ 30,597	$ -	$ 3,053	$ (8,429)	$ (9,026)
Mountain Bay	SC	1	658.0	13839	13813	14104	14157	51.9%	51.8%	52.9%	53.1%	18250	9473	9455	9654	9690	4751	$ 1,096,147	$ 1,094,088	$ 1,117,137	$ 1,121,335	$ -	$ 2,059	$ (20,990)	$ (25,188)
Mullins Ford	SC	1	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	8377	$ 17,178	$ 6,005	$ 17,736	$ 21,786	$ -	$ 11,172	$ (559)	$ (4,609)
New Prospect	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	13059	$ 52,033	$ 38,535	$ 55,952	$ 58,129	$ -	$ 13,498	$ (3,919)	$ (6,096)
Oconee Point	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	9818	$ 37,156	$ 24,225	$ 38,957	$ 39,284	$ -	$ 12,931	$ (1,801)	$ (2,128)
Paynes Creek (outer)	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	8084	$ 30,594	$ 19,947	$ 32,076	$ 32,346	$ -	$ 10,647	$ (1,483)	$ (1,752)
Poplar Spring (left ramp)	GA	1	651.5	2092	1936	2329	2331	7.8%	7.3%	8.7%	8.7%	18250	1432	1325	1594	1596	39738	$ 1,385,933	$ 1,282,585	$ 1,542,944	$ 1,544,269	$ -	$ 103,349	$ (157,011)	$ (158,336)
Poplar Spring (right ramp)	GA	1	643.6	233	168	242	251	0.9%	0.6%	0.9%	0.9%	18250	159	115	166	172	39738	$ 154,362	$ 111,300	$ 160,325	$ 166,287	$ -	$ 43,062	$ (5,962)	$ (11,925)
Port Bass	SC	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	4753	$ 247,647	$ 241,941	$ 284,418	$ 284,259	$ -	$ 5,706	$ (36,771)	$ (36,612)
Portman Shoals	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	143551	$ 543,266	$ 354,200	$ 569,591	$ 574,378	$ -	$ 189,066	$ (26,326)	$ (31,112)
Powder Bag Creek N	GA	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	11024	$ 41,721	$ 27,201	$ 43,742	$ 44,110	$ -	$ 14,520	$ (2,022)	$ (2,389)
Reed Creek	GA	1	657.5	12094	12051	12463	12508	45.4%	45.2%	46.7%	46.9%	18250	8278	8249	8531	8562	4811	$ 970,028	$ 966,579	$ 999,625	$ 1,003,234	$ -	$ 3,449	$ (29,597)	$ (33,206)
Richland Creek	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	14674	$ 55,533	$ 36,207	$ 58,224	$ 58,714	$ -	$ 19,327	$ (2,691)	$ (3,180)
River Forks (left ramp)	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	37251	$ 140,975	$ 91,913	$ 147,807	$ 149,049	$ -	$ 49,062	$ (6,831)	$ (8,073)
Rock Spring	GA	1	644.0	239	177	257	267	0.9%	0.7%	1.0%	1.0%	18250	164	121	176	183	14562	$ 58,024	$ 42,972	$ 62,394	$ 64,822	$ -	$ 15,052	$ (4,370)	$ (6,798)
Rocky Ford	GA	1	657.5	12094	12051	12463	12508	45.4%	45.2%	46.7%	46.9%	18250	8278	8249	8531	8562	9604	$ 1,936,447	$ 1,929,562	$ 1,995,530	$ 2,002,735	$ -	$ 6,885	$ (59,083)	$ (66,288)
Sadlers Creek State Park #1	SC	2	638.0	123	43	127	156	0.5%	0.2%	0.5%	0.6%	18250	84	29	87	107	40116	$ 82,262	$ 28,758	$ 84,938	$ 104,333	$ -	$ 53,504	$ (2,675)	$ (22,070)
Seneca Creek	SC	1	657.0	10332	10289	10868	10909	38.8%	38.6%	40.8%	40.9%	18250	7072	7043	7439	7467	25957	$ 4,471,154	$ 4,452,546	$ 4,703,107	$ 4,720,849	$ -	$ 18,608	$ (231,953)	$ (249,696)
Seymour	GA	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	17408	$ 906,918	$ 886,022	$ 1,041,577	$ 1,040,997	$ -	$ 20,895	$ (134,659)	$ (134,079)
Singing Pines	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	53740	$ 203,378	$ 132,599	$ 213,233	$ 215,025	$ -	$ 70,779	$ (9,855)	$ (11,647)
South Union	SC	1	655.5	6215	6197	6871	6920	23.3%	23.2%	25.8%	26.0%	18250	4254	4242	4703	4737	4795	$ 496,862	$ 495,423	$ 549,307	$ 553,224	$ -	$ 1,439	$ (52,444)	$ (56,362)
Spring Branch	GA	1	649.0	1213	1036	1451	1494	4.5%	3.9%	5.4%	5.6%	18250	830	709	993	1023	15745	$ 318,405	$ 271,944	$ 380,878	$ 392,166	$ -	$ 46,461	$ (62,474)	$ (73,761)

Springfield	SC	1	643.6	233	168	242	251	0.9%	0.6%	0.9%	0.9%	18250	159	115	166	172	18975	$ 73,709	$ 53,146	$ 76,556	$ 79,403	$ -	$ 20,563	$ (2,847)	$ (5,694)
Stephens Co.	GA	1	651.5	2092	1936	2329	2331	7.8%	7.3%	8.7%	8.7%	18250	1432	1325	1594	1596	71408	$ 2,490,520	$ 2,304,802	$ 2,772,668	$ 2,775,049	$ -	$ 185,718	$ (282,148)	$ (284,529)
Tabor	SC	1	652.5	2712	2613	2958	2970	10.2%	9.8%	11.1%	11.1%	18250	1856	1789	2025	2033	11016	$ 498,086	$ 479,904	$ 543,267	$ 545,470	$ -	$ 18,182	$ (45,180)	$ (47,384)
Tillies	SC	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	4780	$ 249,017	$ 243,280	$ 285,992	$ 285,832	$ -	$ 5,737	$ (36,974)	$ (36,815)
Timberland	SC	1	654.0	4468	4379	5097	5121	16.8%	16.4%	19.1%	19.2%	18250	3058	2997	3489	3505	4811	$ 358,367	$ 351,228	$ 408,817	$ 410,742	$ -	$ 7,138	$ (50,450)	$ (52,375)
Townville	SC	1	652.3	2533	2433	2753	2781	9.5%	9.1%	10.3%	10.4%	18250	1734	1665	1884	1904	13901	$ 587,047	$ 563,871	$ 638,034	$ 644,523	$ -	$ 23,176	$ (50,987)	$ (57,476)
Tugaloo State Park (mega)	GA	6	642.0	205	133	222	225	0.8%	0.5%	0.8%	0.8%	18250	140	91	152	154	93552	$ 319,732	$ 207,436	$ 346,246	$ 350,925	$ -	$ 112,296	$ (26,514)	$ (31,193)
Twelve Mile (right lane)	SC	1	647.0	640	548	802	832	2.4%	2.1%	3.0%	3.1%	18250	438	375	549	569	84793	$ 904,730	$ 774,675	$ 1,133,740	$ 1,176,149	$ -	$ 130,055	$ (229,010)	$ (271,419)
Twin Lakes (right ramp)	SC	1	648.0	865	764	1052	1086	3.2%	2.9%	3.9%	4.1%	18250	592	523	720	743	120293	$ 1,734,744	$ 1,532,190	$ 2,109,770	$ 2,177,957	$ -	$ 202,554	$ (375,026)	$ (443,212)
Walker Creek	GA	1	657.0	10332	10289	10868	10909	38.8%	38.6%	40.8%	40.9%	18250	7072	7043	7439	7467	11062	$ 1,905,465	$ 1,897,535	$ 2,004,316	$ 2,011,878	$ -	$ 7,930	$ (98,851)	$ (106,412)
Watsadler	GA	1	645.0	285	243	384	395	1.1%	0.9%	1.4%	1.5%	18250	195	166	263	270	14907	$ 70,830	$ 60,392	$ 95,435	$ 98,169	$ -	$ 10,438	$ (24,604)	$ (27,338)
Weldon Island	SC	1	643.0	227	148	238	240	0.9%	0.6%	0.9%	0.9%	18250	155	101	163	164	9090	$ 34,400	$ 22,428	$ 36,067	$ 36,370	$ -	$ 11,972	$ (1,667)	$ (1,970)
White City	SC	1	653.0	3125	3053	3589	3587	11.7%	11.5%	13.5%	13.5%	18250	2139	2090	2457	2455	16432	$ 856,090	$ 836,366	$ 983,202	$ 982,654	$ -	$ 19,724	$ (127,112)	$ (126,564)

Table 4.3-10 Economic Value of Recreation Impacts

USACE PROJECT	ANNUAL VISITATION TO RECREATION AREAS	# UNAVAILABLE RAMP DAYS	RAMP-DAY IMPACTS (DAYS)	TOTAL VALUE OF IMPACT (50 YEARS)	PRESENT WORTH OF ANNUAL IMPACT
NAA / A1					
Hartwell	2,171,405	171,374	---	---	---
J. Strom Thurmond	1,805,742	60,869	---	---	---
Alternative 2					
Hartwell	2,171,405	166,104	-5,270	-$2,955,567*	
J. Strom Thurmond	1,805,742	61,605	736	$910,744	
				-$2,044,823*	-$898,370*
Alternative 3					
Hartwell	2,171,405	182,410	11,036	$4,718,945	
J. Strom Thurmond	1,805,742	63,411	2,542	$964,568	
				$5,683,512	$2,937,573
Alternative 4					
Hartwell	2,171,405	183,555	12,181	$5,199,358	
J. Strom Thurmond	1,805,742	64,485	3,616	$1,371,134	
				$6,570,492	$3,626,374

Note: Impacts based on comparing ramp day availability to that in the No Action Alternative
Annual Value of Impact = Annual Visitation x % Ramp-Day Impacts x Unit-Day Value
Negative impacts at Hartwell mean that higher pools would increase recreational use
Present worth based on 50-year period of analysis and interest rate of 3.5%

To address these impacts to recreation users of the USACE reservoirs, Duke Energy would provide funding, in-kind services, contractor services or combinations of the same to USACE and other public entities that operate public boat launching facilities on Hartwell and Thurmond Reservoirs ("Public Boat Ramp Operators") to improve public boat launching facilities.

USACE will oversee the mitigation program to ensure the adverse impacts to recreational users of the USACE reservoirs are fully addressed. The mitigation would be implemented in several locations on each reservoir to address the impacts that are distributed around those lakes. At present, the improvements are expected to be provided at ramps on Hartwell and Thurmond. The mitigation may include extending existing ramps so they provide access when the reservoirs are lower, constructing new ramps, improving access at existing ramps, improving parking at existing ramps, etc.

If funding is provided to USACE, Duke will provide the estimated cost prior to the work being performed. USACE will provide Duke with an accounting of the expenditures and return any amount that was not used for that specific purpose.

Duke Energy would contribute an amount equal to the estimated adverse effects identified to recreational users on Hartwell and Thurmond Reservoirs. That amount would fully compensate for the expected impacts identified to recreational users.

4.4 Biotic Communities

Common names for species are referenced throughout the main body of this EA. Cross-reference tables that provide both the common names and scientific names for each species are provided in Appendix E as follows:

- Fish species Table E-1
- Aquatic plants Table E-2
- Wetland species Table E-3
- Wildlife species Tables E-4 through E-9

4.4.1 *Fish and Mussel Critical Habitat and Seasons*

Detailed descriptions of the fish and mussel resources in the Savannah River reservoirs and the mainstem Savannah River downstream from JST are provided in Section 2.9. Reservoir elevation results for the entire 73-year POR were analyzed for potential impacts to fish and mussel communities. Critical habitats and time periods, including reservoir littoral zone fish spawning habitat (April, May, and June), reservoir pelagic cool water/forage fish habitat (September), and reservoir littoral zone mussel habitat (annual) were assessed to evaluate differences between modeled reservoir operating scenarios. Differences in daily lake level fluctuations were the basis for the littoral zone assessment, while mean September reservoir elevations were analyzed for pelagic habitats. Similarly, critical time periods during the year were analyzed for the lower Savannah River downstream from JST Lake. These included riverine spawning (February-May), outmigration (May-August), summer low flow (August-November), and overwintering (November-February) periods. JST mean monthly flows were used for this assessment. HEC-ResSim model results for all four model scenarios are provided below for each critical time period in the Duke Energy and USACE reservoirs, as well as the lower Savannah River.

4.4.1.1 *Duke Energy Reservoir Littoral Zone Fish Habitat*

Similar to many reservoir fisheries in the southeastern U.S., centrarchids (e.g., sunfish and largemouth bass) make up the majority of the littoral zone species abundance in the Duke Energy Reservoirs. Many of these species create nests in littoral zone habitats where potential for nest/egg exposure can occur with reservoir level fluctuations. Unlike the USACE Reservoirs, there is currently no guideline for Duke Energy to maintain reservoir elevations during spring black bass spawning, which typically peaks in April. Sunfish spawning typically peaks in May and June. The average and range of daily reservoir fluctuations during the spawning months of April, May, and June are provided in Tables 4.4-1, 4.4-2, and 4.4-3, respectively.

Future Water Withdrawals with Historic Hydrology

During spawning months in Lakes Jocassee and Keowee, there is very little (0.01 feet) to no difference in average daily fluctuations between the alternatives. In Lake Jocassee, the maximum rise and fall of A2 daily fluctuations is 2 – 3 feet greater than the other model scenarios. Although a daily drop in reservoir elevation of 2 feet could cause nests to become exposed, pump-back operations often result in a similar increase the following day. Such large daily pool variations make those sites unsuitable for spawning by littoral zone fish. Five years of littoral zone electrofishing (1996, 1999, 2002, 2005, and 2008) conducted by Duke Energy found increasing numbers and weights of centrarchids (10 species combined) during two extreme drought periods (i.e., 1998 – 2002 and 2007 – 2008). Rodriguez (2009) suggests fish populations in Lake Jocassee are more limited by nutrient inputs than reservoir elevations. It is also likely that centrarchids have acclimated to the daily reservoir elevation fluctuations in Lake Jocassee and they have selected deeper spawning sites, as have been observed in other pumped storage reservoirs (Estes 1971).

Model Sensitivity Analyses

Modeling current water withdrawals had little effect on the average daily fluctuations in the Duke Energy Reservoirs. A2 produced the greatest daily maximum and minimum fluctuation (0.1 to 1.3 feet) in both Lakes Jocassee and Keowee.

Modeling climate change hydrologic conditions results in the same daily average fluctuation for all alternatives, but with greater (0.1 to 1.5 feet) maximum declines in pool levels during April. Similar to the future water withdrawals with historic hydrology scenario, these differences in the sensitivity analyses are unlikely to affect littoral zone fish spawning success.

4.4.1.2 *USACE Reservoir Littoral Zone Fish Habitat*

State natural resource agencies have identified largemouth bass spawning as a high priority for all of the USACE impoundments on the Savannah River. SC DNR personnel indicate that largemouth bass initiate spawning in the USACE reservoirs when water temperatures reach 18°C (65°F) and cease spawning when water temperatures reach 21°C (70°F) (USACE 2008a). With peak spawning likely occurring in April, USACE targets stable pool levels to prevent exposed and/or abandoned centrarchids nests and eggs. The USACE limits the lowering of reservoir elevations to 6 inches or less during the spawning period unless high inflows and/or drought conditions exist. The average and range of daily reservoir fluctuations during the spawning months of April, May, and June are provided in Tables 4.4-1, 4.4-2, and 4.4-3, respectively.

Future Water Withdrawals with Historic Hydrology

As discussed in Section 3.5, model results for the USACE reservoirs are very similar for all four alternatives, including April-June reservoir elevations. During the spawning months in Hartwell, RBR, and JST Lakes, there is very little (0.01 foot) to no difference in average daily fluctuations between the alternatives. As expected, there are rare instances when the maximum rise and fall of daily fluctuations exceeds the 6-inch rule, with the greatest of these instances occurring in RBR Lake. However, these differences occur very infrequently (5 percent or less of the time during spawning months) and the magnitudes of these differences are similar between scenarios. Overall, such minor and infrequent differences between scenarios would not have a negative effect on littoral zone spawning in the USACE reservoirs.

Model Sensitivity Analyses

Modeling current water withdrawals and climate change hydrologic conditions had very little (0.01 foot) to no effect on the average daily fluctuations in the USACE Reservoirs when compared to the future water withdrawals with historic hydrology. Modeling sensitivity analyses result in minor differences in maximum rise and fall. For example, A2's maximum fall in Hartwell Lake is less (by approximately 1 foot) for both sensitivity analyses than the future water withdrawals with historic hydrology. The effects of all four alternatives on littoral zone fish spawning are expected to be similar.

4.4.1.3 *Duke Energy Reservoir Littoral Zone Mussel Habitat*

Although mussel populations are not abundant in the Duke Energy reservoirs, reservoir elevation fluctuations could lead to exposure and mortality of mussels in the littoral zone. The severity of the impact would be related to the rate, frequency, and magnitude of daily reservoir fluctuations. Seasonal and meteorological influences may delay (i.e., cool, wet weather) or exacerbate (i.e., hot, dry weather) mortality of mussels during short periods of exposure. However, dewatering during even brief periods under survivable conditions make mussels more susceptible to predation by birds and/or small mammals (Devine Tarbell and Associates 2008). The average and range of daily reservoir fluctuations during the full POR is provided in Table 4.4-4.

Future Water Withdrawals with Historic Hydrology

Similar to littoral zone fish spawning, an analysis of daily reservoir fluctuations was performed to assess potential impacts to littoral zone mussel communities/habitats. All months in the 73-year POR were considered in this mussel habitat analysis (as opposed to only April-June fluctuations for fish). In Lakes Jocassee and Keowee, there is no difference in average daily fluctuations between the alternatives. In Lake Jocassee, the maximum rise and fall of A2 daily fluctuations is 1-2 feet larger (compared to the other three reservoir operating scenarios). As a result, A2 would result in greater potential impacts to mussels.

Model Sensitivity Analyses

Modeling current water withdrawals had no effect on the average daily fluctuations in the Duke Energy reservoirs, but some minimal differences in maximum rise and fall. For example, all alternatives in both reservoirs showed increases in the maximum rise (0.5-3.5 feet) and fall (0.7-1.7 feet). The magnitude of this change was similar between alternatives.

Modeling climate change hydrologic conditions results in the same average daily fluctuation for all alternatives, but with some larger differences in maximum rise and fall. Similar to the current water withdrawal scenario, all alternatives show increases in maximum rise (0.7-4.5 feet) and fall (0.2-2.9 feet). A short-term impact to some individuals would be expected with a 4.4 foot daily drop in elevation (NAA/A1 maximum drop under the future water withdrawals with climate change hydrologic conditions). However, the magnitudes are similar between alternatives.

4.4.1.4 *USACE Reservoir Littoral Zone Mussel Habitat*

No information on mussel communities in the USACE reservoirs was available for this report. However, similar to effects on mussels in the Duke Energy reservoirs, exposure and mortality of mussels could occur in littoral zone areas as a result of daily reservoir fluctuations. The average and range of daily reservoir fluctuations during the full POR are provided in Table 4.4-4.

Future Water Withdrawals with Historic Hydrology

There is no difference in the average daily reservoir fluctuation over the POR between the alternatives for all three of the USACE reservoirs, and little to no difference between maximum rise (0.1-0.3 feet) and fall (0.01-0.4 feet) in the entire POR, particularly for RBR and JST Reservoirs. There were some differences in the maximum daily rise in Hartwell Lake, with A2 producing the greatest rise (1.0 foot). However, a sudden rise in reservoir elevation would not impact mussel populations (only sudden drops). The effects of all four alternatives on mussel populations in the USACE reservoirs are similar.

Model Sensitivity Analyses

Modeling current water withdrawals and climate change hydrologic conditions had no effect on the average daily fluctuations in the USACE reservoirs, but some minor differences in maximum rise and fall are observed. Similar to the sensitivity analysis for littoral zone spawning, all alternatives show increases in the maximum rise (0.1-2.0 feet) and fall (0.3-2.0 feet) under the current water withdrawal with historic hydrology. However, the magnitudes between alternatives are similar. With climate change hydrology, differences in maximum rise also increase for all alternatives, but at a similar magnitude. The effects of all four alternatives on mussel populations in the USACE reservoirs are similar.

Table 4.4-1 Duke Energy and USACE Reservoir Daily Fluctuations in April for the 73-Year POR (1939–2011)

Model Setup	Parameter (feet)	Jocassee				Keowee				Hartwell				RBR				JST			
		NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4
Future Water Withdrawals with Historic Hydrology	Max Rise	2.00	4.00	2.10	2.10	1.23	1.23	0.83	1.02	0.66	0.66	0.69	0.66	1.69	1.69	1.65	1.50	0.72	0.72	0.73	0.73
	Max Fall	-1.60	-2.60	-0.90	-0.90	-0.37	-1.16	-0.37	-0.37	-2.10	-2.10	-2.11	-2.08	-1.74	-1.74	-2.25	-2.25	-1.67	-1.67	-1.67	-1.68
	Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.02	0.02	0.02	0.02
Current Water Withdrawals with Historic Hydrology	Max Rise	1.30	3.70	1.10	0.90	0.40	1.13	0.47	0.46	0.89	0.89	0.75	0.75	2.63	2.63	2.42	1.30	0.69	0.69	0.69	0.68
	Max Fall	-1.50	-3.10	-0.80	-0.80	-0.75	-1.19	-0.48	-0.48	-1.01	-0.99	-1.05	-1.05	-2.21	-2.21	-2.00	-2.00	-2.39	-2.39	-2.92	-2.91
	Average	-0.03	-0.04	-0.03	-0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Future Water Withdrawals with Climate change Hydrology	Max Rise	1.50	3.60	0.90	0.90	0.42	1.19	0.43	0.42	0.68	0.68	0.89	0.84	2.23	2.23	1.98	2.17	0.69	0.69	0.69	0.69
	Max Fall	-1.70	-3.20	-1.50	-1.50	-1.49	-1.57	-0.50	-0.47	-1.29	-1.29	-1.12	-1.12	-1.56	-1.56	-2.04	-2.03	-2.39	-2.39	-2.91	-2.91
	Average	-0.03	-0.03	-0.03	-0.03	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00

Table 4.4-2 Duke Energy and USACE Reservoir Daily Fluctuations in May for the 73-Year POR (1939–2011)

Model Setup	Parameter (feet)	Jocassee				Keowee				Hartwell				RBR				JST			
		NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4
Future Water Withdrawals with Historic Hydrology	Max Rise	1.30	2.90	1.40	1.60	1.13	1.20	0.63	0.53	0.59	0.59	0.88	0.88	3.02	3.02	1.50	1.50	0.61	0.61	0.75	0.75
	Max Fall	-1.40	-2.50	-1.30	-1.30	-0.67	-1.19	-0.44	-0.50	-0.70	-0.70	-1.08	-1.22	-3.77	-3.77	-4.03	-3.95	-1.93	-1.84	-1.82	-1.82
	Average	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.00	0.01	0.01	0.01	0.02	0.02
Current Water Withdrawals with Historic Hydrology	Max Rise	1.80	4.10	2.10	2.20	1.25	1.25	0.87	0.99	0.87	0.87	0.74	0.89	1.69	1.68	1.60	1.61	0.72	0.72	0.72	0.72
	Max Fall	-0.70	-3.80	-0.40	-0.40	-0.45	-1.13	-0.54	-0.54	-2.11	-2.11	-2.10	-2.08	-2.04	-2.04	-1.76	-2.03	-1.67	-1.67	-1.68	-1.69
	Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.02	0.02	0.01	0.02
Future Water Withdrawals with Climate change Hydrology	Max Rise	2.10	4.00	2.20	2.10	1.23	1.23	0.83	0.84	0.75	0.75	0.69	0.69	1.76	1.76	1.65	1.61	0.73	0.73	0.73	0.73
	Max Fall	-1.70	-2.70	-0.90	-0.80	-0.37	-1.14	-0.37	-0.37	-2.10	-2.10	-2.11	-2.11	-1.89	-1.89	-2.25	-2.25	-1.67	-1.67	-1.67	-1.67
	Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.02	0.02	0.02	0.02

Table 4.4-3 Duke Energy and USACE Reservoir Daily Fluctuations in June for the 73-Year POR (1939–2011)

Model Setup	Parameter (feet)	Jocassee				Keowee				Hartwell				RBR				JST			
		NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4
Future Water Withdrawals with Historic Hydrology	**Max Rise**	1.30	2.90	1.40	1.60	1.13	1.13	0.92	0.91	0.37	0.41	0.59	0.63	2.00	2.02	1.58	1.58	0.61	0.62	0.52	0.52
	Max Fall	-1.40	-2.40	-1.30	-1.30	-0.67	-1.19	-0.45	-0.50	-0.91	-0.91	-1.08	-1.22	-1.91	-1.94	-1.79	-1.93	-1.93	-1.84	-1.82	-1.82
	Average	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.02	0.02	0.02	0.02
Current Water Withdrawals with Historic Hydrology	**Max Rise**	1.50	3.60	0.80	0.80	1.06	1.12	1.24	1.23	0.58	0.67	0.42	0.44	3.01	3.01	1.51	1.53	0.56	0.56	0.75	0.74
	Max Fall	-1.30	-2.50	-1.30	-1.30	-0.67	-1.11	-0.53	-0.52	-1.26	-1.26	-1.15	-1.16	-3.88	-3.88	-4.02	-4.23	-1.58	-1.61	-1.59	-1.60
	Average	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02
Future Water Withdrawals with Climate change Hydrology	**Max Rise**	1.40	3.50	1.70	1.60	0.82	1.13	0.50	0.53	0.85	0.85	0.88	0.88	3.02	3.01	1.52	1.50	0.62	0.62	0.74	0.74
	Max Fall	-1.00	-2.60	-1.20	-1.30	-0.67	-1.16	-0.44	-0.50	-1.28	-0.65	-1.06	-1.06	-3.74	-3.74	-4.02	-3.92	-2.02	-1.93	-1.82	-1.82
	Average	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.02	0.02	0.02

Table 4.4-4 Duke Energy and USACE Reservoir Year-Round Daily Fluctuations for the 73-Year POR

Model Setup	Parameter (feet)	Jocassee				Keowee				Hartwell				RBR				JST			
		NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4	NAA / A1	A2	A3	A4
Future Water Withdrawals with Historic Hydrology	**Max Rise**	1.40	3.70	0.90	0.90	0.43	1.17	0.43	0.42	0.68	0.68	0.89	0.84	2.23	2.23	2.11	2.11	0.69	0.69	0.69	0.69
	Max Fall	-1.70	-3.20	-1.40	-1.50	-1.48	-1.48	-0.50	-0.51	-1.22	-1.22	-1.12	-1.13	-2.43	-2.43	-2.04	-2.03	-2.38	-2.38	-2.92	-2.90
	Average	-0.03	-0.03	-0.03	-0.03	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Current Water Withdrawals with Historic Hydrology	**Max Rise**	5.00	4.30	3.10	3.20	1.68	1.68	1.66	1.77	0.91	2.69	1.03	0.91	3.35	2.42	3.35	3.37	0.76	0.76	0.75	0.76
	Max Fall	-2.80	-4.40	-3.10	-2.80	-2.33	-2.18	-2.18	-2.14	-2.93	-2.93	-2.93	-2.93	-3.88	-2.75	-4.02	-4.23	-3.89	-3.89	-4.01	-4.04
	Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Future Water Withdrawals with Climate change Hydrology	**Max Rise**	4.40	4.40	2.80	2.70	1.67	1.67	1.64	1.67	0.92	3.14	1.12	1.63	3.02	2.51	3.65	4.18	0.76	0.76	0.76	0.76
	Max Fall	-4.40	-3.50	-4.10	-4.10	-1.64	-1.78	-1.59	-1.61	-2.80	-2.73	-2.81	-2.82	-3.74	-2.74	-4.02	-4.50	-3.82	-3.82	-3.36	-3.17
	Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.4.1.5 *Duke Energy Reservoir Pelagic Zone Fish Habitat*

Blueback herring and trout are important cool water forage and game fish, respectively, in the Duke Energy reservoirs. Although populations of these species are supplemented through stocking, pelagic habitat during hot and dry summer conditions can limit populations. The optimal temperature for blueback herring is 20°C (68°F) to 25°C (77°F), with D.O. > 4.0 mg/L (Nestler et al. 2002).

The pelagic trout fishery is unique to Lake Jocassee and its sustainability is partially dependent on the availability of suitable pelagic habitat; specifically, a hypolimnion that possesses water temperatures <20°C (68°F) with D.O. >5 mg/L during the critical summer and fall months. During extreme droughts, Lake Jocassee can experience periods of relatively low reservoir elevations. However, reservoir elevations alone have not been found to influence the amount of pelagic trout habitat. Therefore, the Lake Jocassee trout fishery is not expected to be negatively affected by any of the alternatives (William Foris, Duke Energy, Personal Communication, October 15, 2013). Pelagic habitats were further assessed by comparing mean September reservoir elevations. The mean September reservoir elevations for the 73-year POR are provided in Figures 4.4-1 and 4.4-2.

There is an increased risk of fish entrainment associated with pumping operations at the Bad Creek Project when Lake Jocassee reservoir elevations fall below 1,096 feet AMSL (Barwick et al 1994). Over the 73-year POR, Lake Jocassee daily reservoir elevations drop below 1,096 feet AMSL 12 percent of the time for the NAA/A1 and A2, and 4 percent of the time for A3 and A4. So A3 and A4 would reduce the risk of fish entrainment at the Bad Creek Project.

Future Water Withdrawals with Historic Hydrology

As discussed in Section 3.4 for the Duke Energy Reservoirs, A3 and A4 generally result in higher reservoir elevations compared to NAA/A1 and A2. A3 and A4 produce the highest mean September reservoir elevations (approximately 5-14 feet higher than NAA/A1 and A2) in Lake Jocassee. Differences between the alternatives in mean September elevations occur during 23 years for Lake Jocassee and 46 years for Lake Keowee over the POR. The greatest differences occur in Lake Jocassee between NAA/A1 and A2 compared to A3 and A4. For example, in

September 1988, NAA/A1 and A2 are 12 feet lower than A3 and A4. NAA/A1 and A2 Lake Jocassee elevations were 10 feet lower than A3 and A4 during the 2001 extreme drought year.

Lake Keowee reservoir elevations follow the same general pattern as Lake Jocassee (differences in elevations occur between NAA/A1 and A2 compared to A3 and A4). On occasion, NAA/A1 results in lower reservoir elevations (by up to 5 feet) compared to A2 (2008). Although some of the differences between alternatives are relatively large during certain drought periods, they are infrequent and would not be expected to have an effect on the long term sustainability of cool water forage and predator fish populations in the Duke Energy reservoirs. Reservoir elevations alone have not been found to influence the amount of pelagic trout habitat in Lake Jocassee. Therefore, the Lake Jocassee trout fishery should not be negatively affected by any of the alternatives.

Model Sensitivity Analyses

Modeling current water withdrawals result in slightly higher September mean elevations in both reservoirs, which under favorable meteorological conditions, would increase pelagic cool water fish habitat under all alternatives compared to the future water withdrawal with historic hydrology. Reducing water withdrawals also results in smaller differences between scenarios. For example, differences between A3 and A4 compared to A2 for Lake Jocassee range from 2-10 feet (instead of 5-14 feet).

Climate change hydrologic conditions result in similar differences between scenarios compared to future water withdrawals with historic hydrology model assumptions. A3 and A4 result in higher mean elevations. When the reservoirs are strongly stratified, lower lake elevations could “squeeze” preferred habitats into a smaller zone and potentially compress species into less preferred habitats. Based on the model results, these conditions would likely affect Lake Keowee more than Lake Jocassee. However, the infrequent nature of these events is not expected to have long-term consequences on pelagic fish populations in the Duke Energy reservoirs.

Figure 4.4-1 Lake Jocassee Mean September Elevation for Future Water Withdrawals with Historic Hydrology

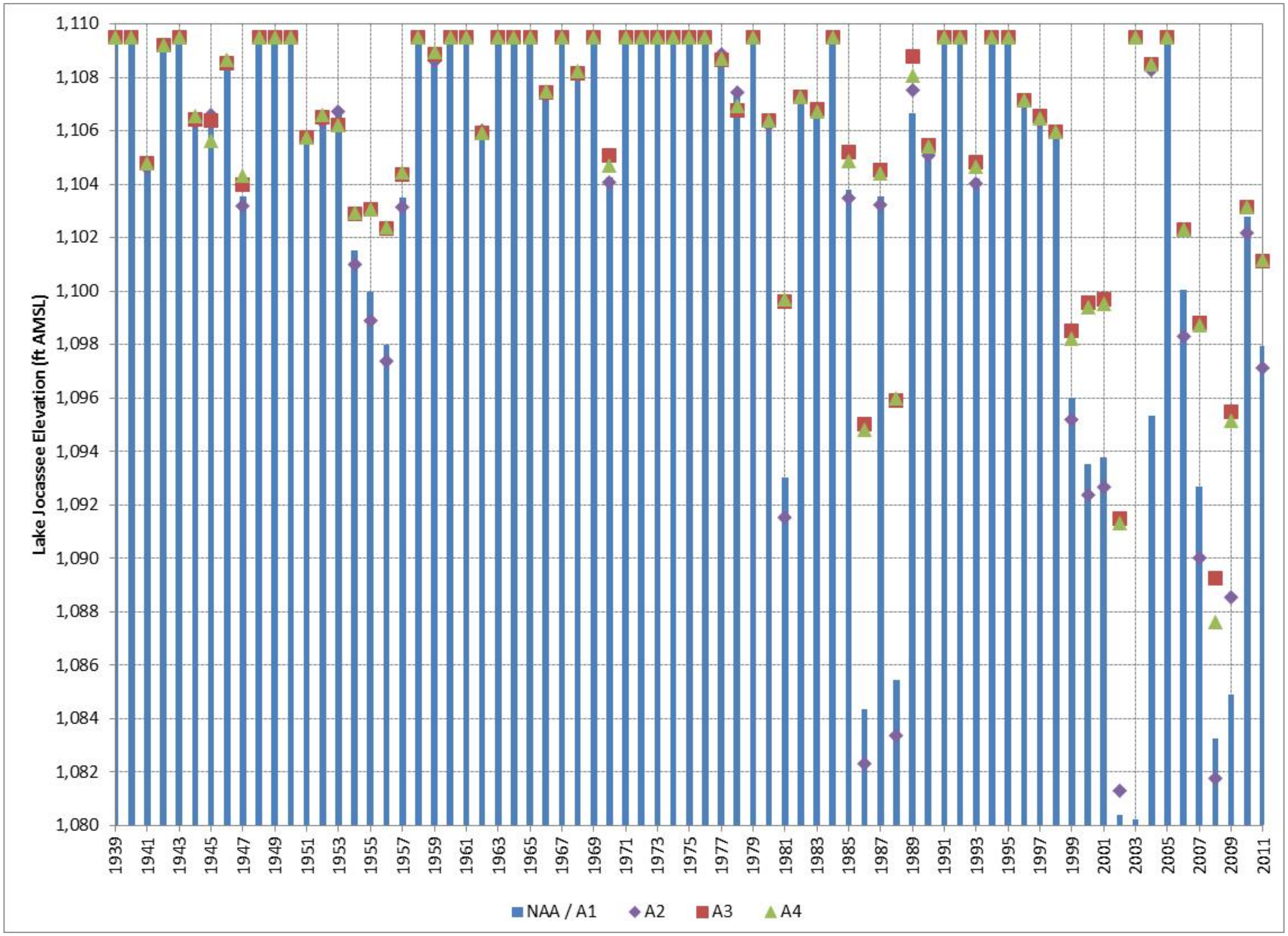
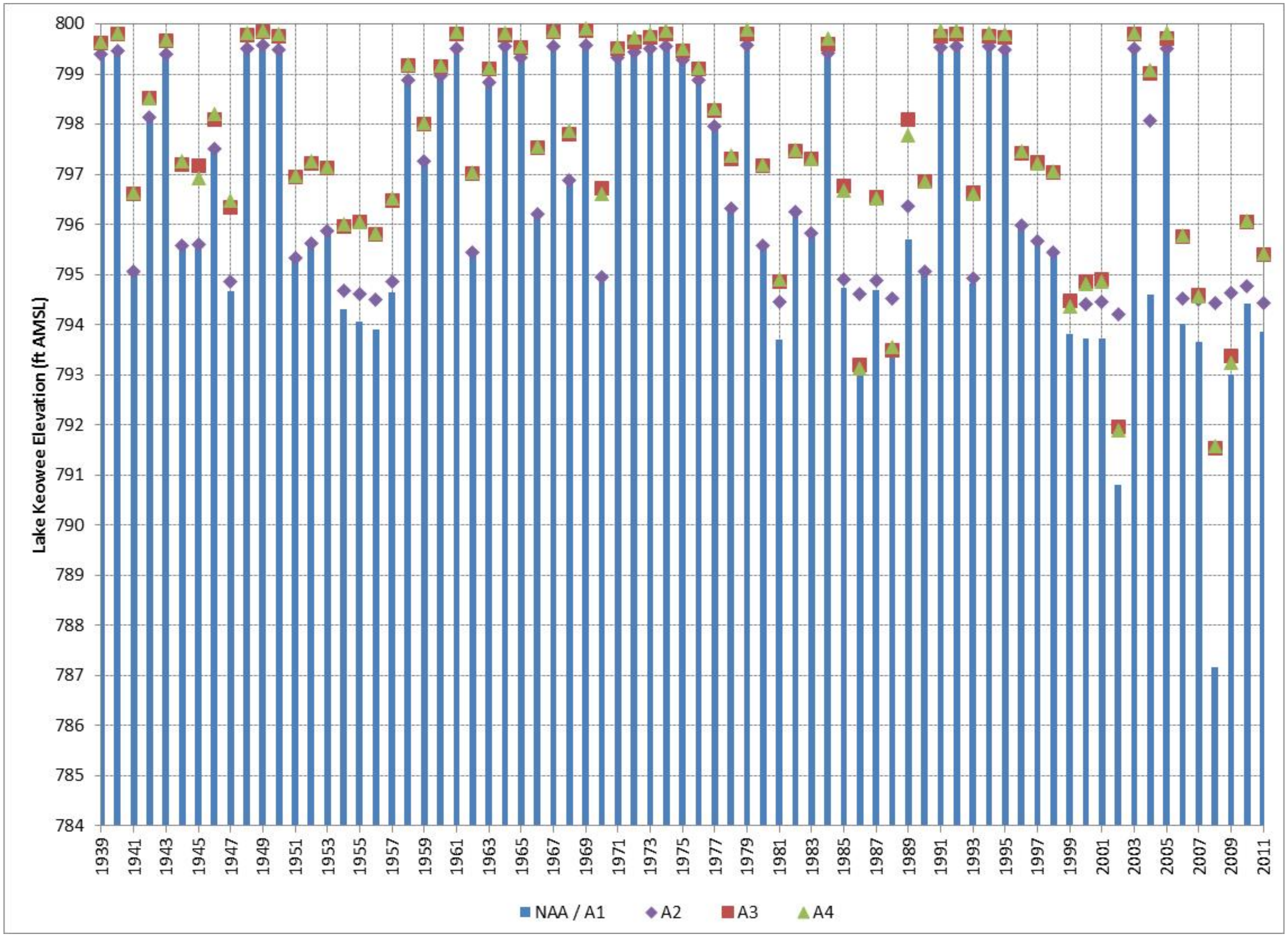


Figure 4.4-2 Lake Keowee Mean September Elevation for Future Water Withdrawals with Historic Hydrology



Appendix O provides the mean September reservoir elevation graphs for the HEC-ResSim model sensitivity analyses for the Duke Energy reservoirs.

4.4.1.6 *USACE Reservoir Pelagic Zone Fish Habitat*

Blueback herring and temperate bass are important forage and game fish, respectively, in the USACE reservoirs. Although populations of striped bass are supplemented through stocking, pelagic habitat during hot and dry summer conditions can limit populations for these species. Similar optimal water quality conditions as those reported for the Duke Energy reservoirs are also required for summer survival within the USACE reservoirs. Varying lake elevations from year to year could shift the location of preferred habitat in each USACE reservoir, which could result in a smaller volume of preferred habitat. However, because the differences in reservoir elevation between alternatives are small, it is expected that all four alternatives would have similar effects on the amount of preferred habitat in each reservoir. The mean September reservoir elevations are provided in Figures 4.4-3, 4.4-4, and 4.4-5.

Future Water Withdrawals with Historic Hydrology

There is very little to no difference (< 1 foot) between mean September elevations for the alternatives in all three USACE reservoirs. These small and infrequent differences are not expected to impact pelagic fish habitat in these reservoirs.

Model Sensitivity Analyses

Modeling current water withdrawals resulted in slightly higher September mean elevations for all three USACE reservoirs, but differences between alternatives are still very small (< 1 foot).

Modeling climate change hydrologic conditions results in no difference or only slightly lower September mean reservoir elevations in all three USACE reservoirs compared to historic hydrologic conditions. For the most part, differences between alternatives are very small (< 1 foot) in all three USACE reservoirs. However there are two years at RBR Lake where the differences were slightly greater than 1 foot (i.e., 1969 and 1979). The infrequent nature of these events and small differences in reservoir elevations between alternatives is not expected to affect pelagic fish populations in the USACE reservoirs.

Appendix O provides the mean September reservoir elevation graphs for the HEC-ResSim model sensitivity analyses for the USACE reservoirs.

Figure 4.4-3 Hartwell Lake Mean September Elevation (Future Water Withdrawals with Historic Hydrology)

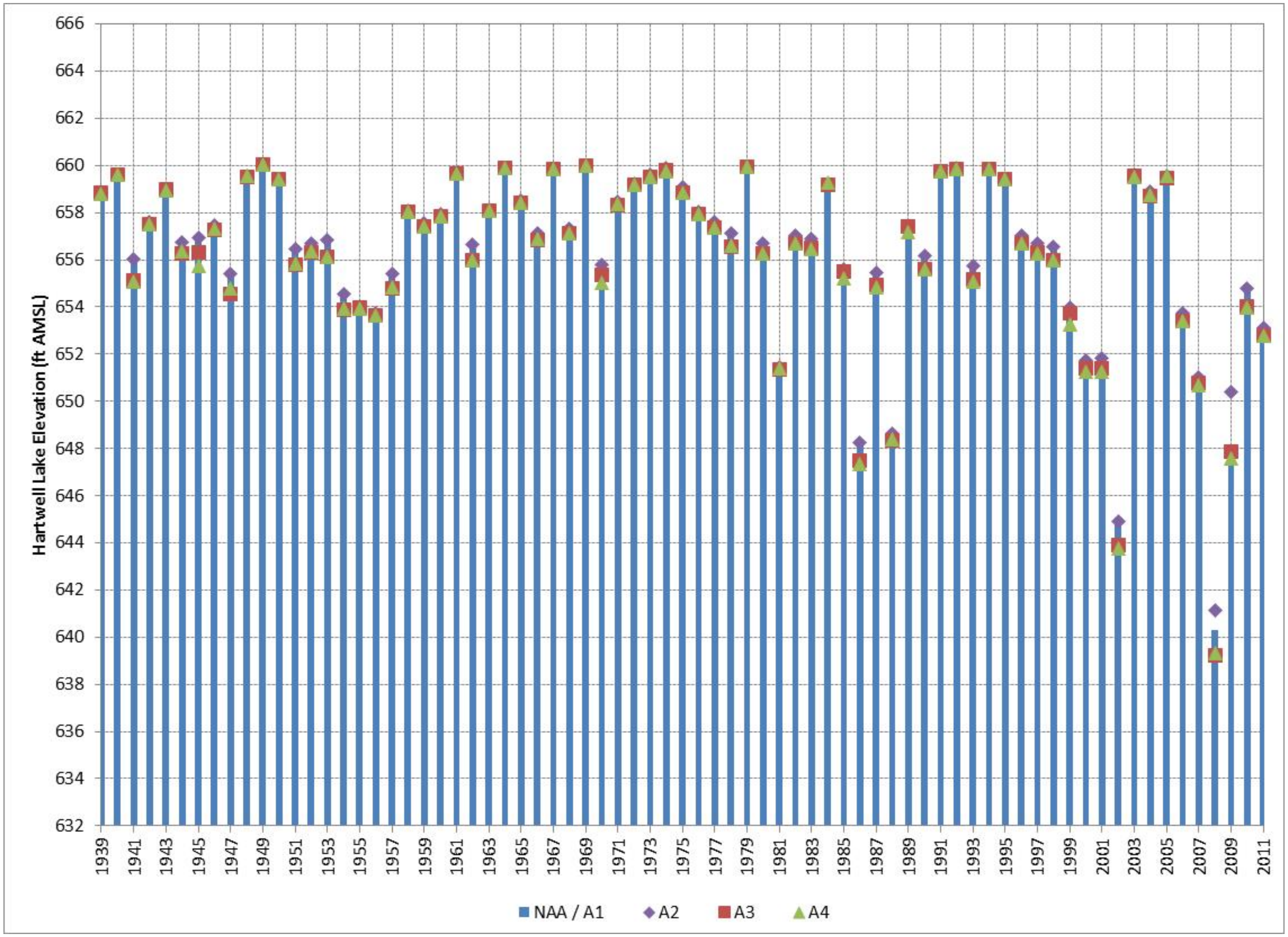


Figure 4.4-4 RBR Lake Mean September Elevation (Future Water Withdrawals with Historic Hydrology)

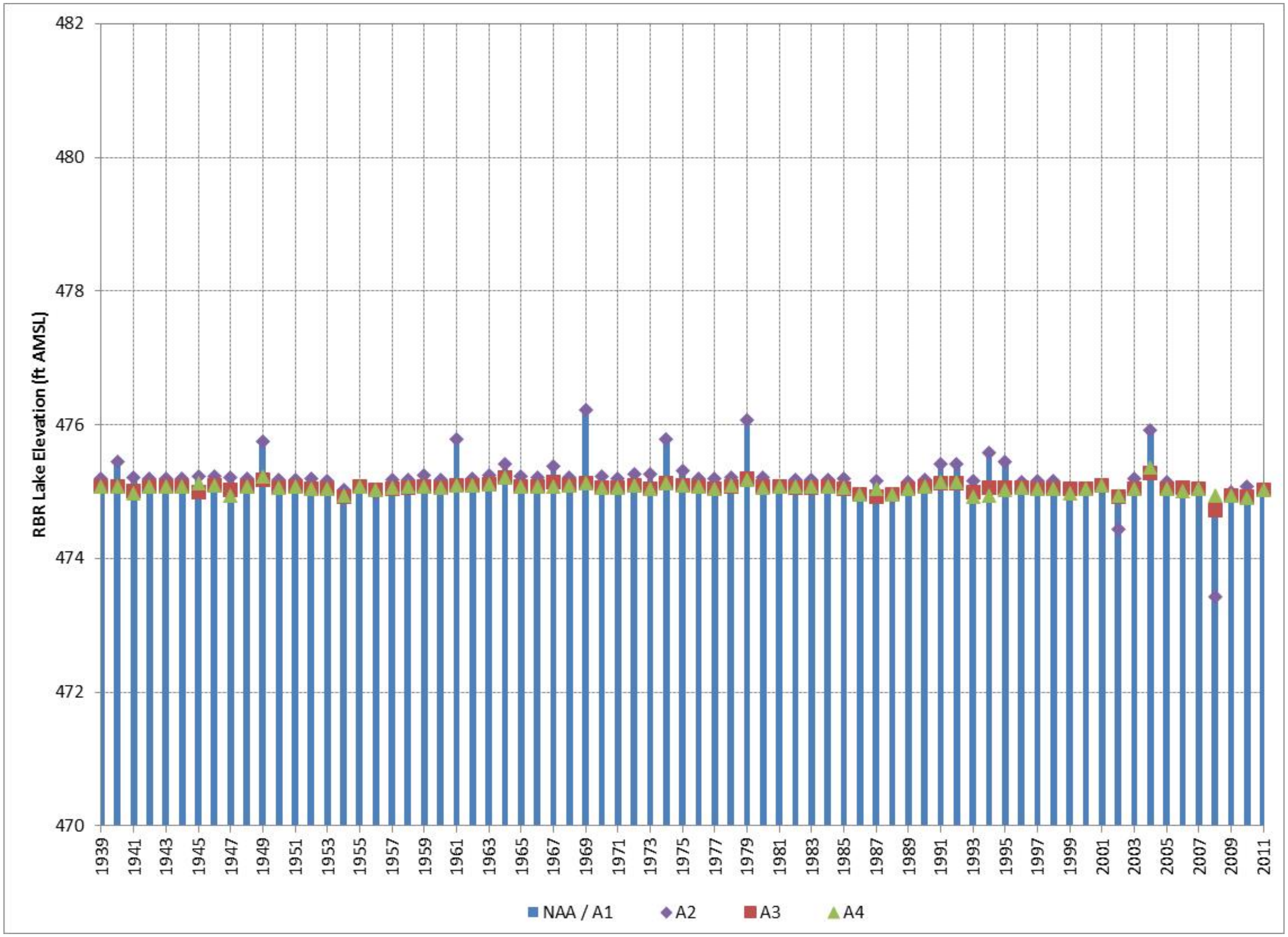
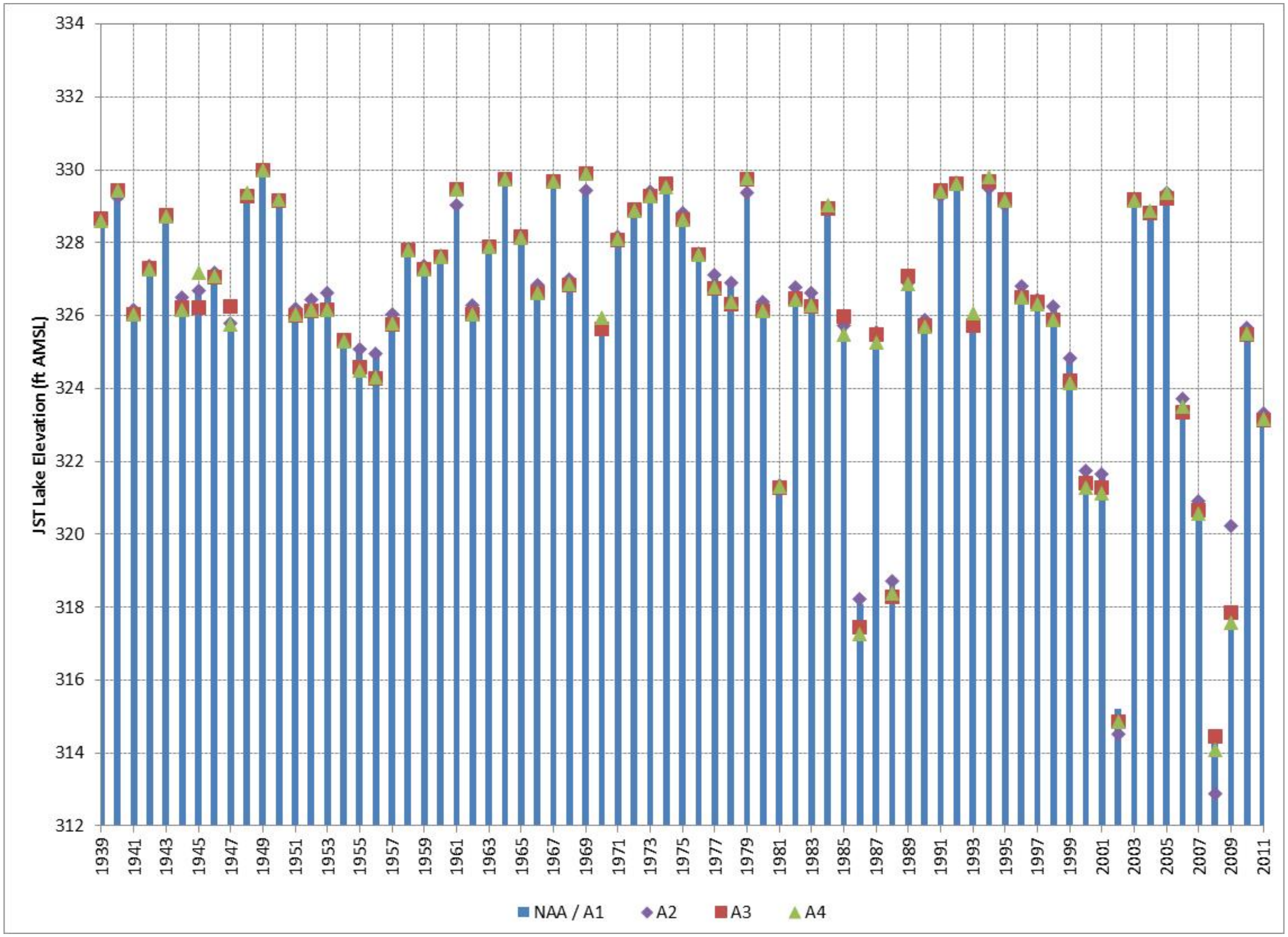


Figure 4.4-5 JST Lake Mean September Elevation (Future Water Withdrawals with Historic Hydrology)



4.4.1.7 *Lower Savannah River Fish and Mussel Habitats*

As mentioned in Section 2.9.1.6, the Savannah River downstream from JST Reservoir supports an abundant and diverse fish community including resident freshwater, euryhaline, and diadromous species. Augusta Shoals and other gravel bars downstream from JST are known spawning habitats for many fish species including striped bass, shad, endangered sturgeon, suckers, and other riverine species (Duncan et al. 2003). Sufficient river flows during spawning runs, larval drift and juvenile outmigration, and overwintering are important for completion of diadromous and resident fish life cycles. Summer low flow periods, particularly during drought years can reduce wetted perimeters and limit instream habitats. These periods create stressful conditions for fish and mussel species and during extreme circumstances can result in fish and mussel mortalities. Mean monthly flows were used to assess potential effects on critical time periods for fish and mussel communities in the lower Savannah River downstream from JST Lake. Figures 4.4-6 through 4.4-17 provide monthly mean flow data (January through December). Similar to mean flow data presented in Section 3.7, differences between alternatives are minor.

Future Water Withdrawals with Historic Hydrology

All four alternatives result in similar reservoir elevations for the USACE reservoirs. As a result, flow releases to the lower Savannah River downstream from JST are also similar. Where there are differences, they typically occur during higher flow periods when monthly average JST flow releases are well above 10,000 cfs. Monthly average differences in flows released from JST were not as evident during drought conditions, and in particular extreme drought conditions. For example, during the extreme drought in 2008, there was little to no difference in average monthly JST releases between alternatives. Therefore, the effects of all four alternatives on lower Savannah River fish and mussel populations are expected to be similar.

Model Sensitivity Analysis

Current water withdrawals result in slightly higher monthly releases from JST compared to future water withdrawals. There is little to no difference in JST releases between current water withdrawal model scenarios. Where there are differences in monthly average JST flow releases, they typically occur during high flow events (i.e., in excess of 10,000 cfs). As a result, any effects to lower Savannah River fish and mussel populations are expected to be similar for the four current water withdrawal modeling scenarios.

Modeling climate change hydrologic conditions results in similar mean monthly releases from JST compared to historic hydrologic conditions. The effects of all four alternatives on lower Savannah River fish and mussel populations are expected to be similar.

Appendix O provides the monthly mean flow figures (January-December) for the Savannah River model sensitivity analyses.

Figure 4.4-6 Mean January JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

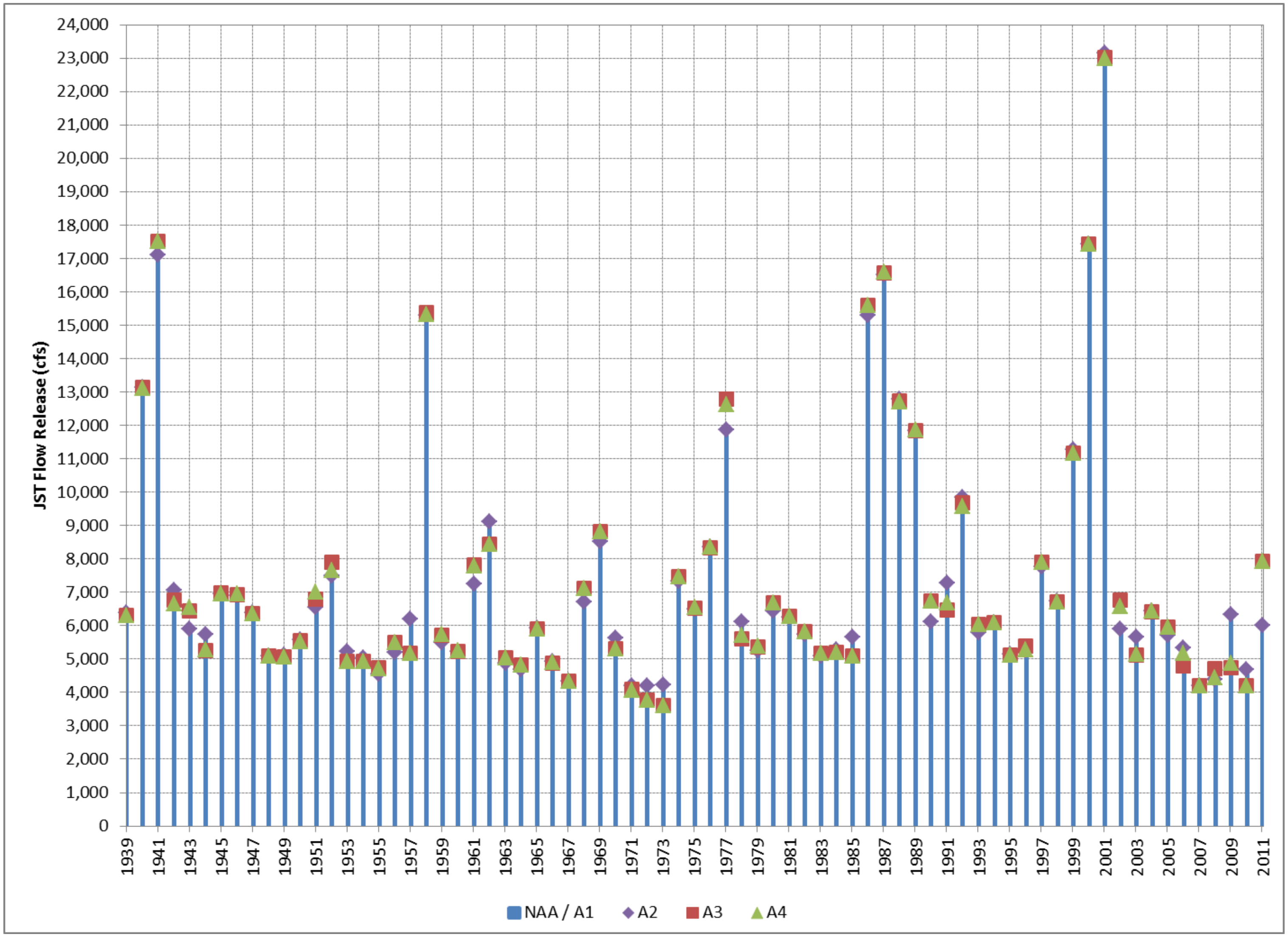


Figure 4.4-7 Mean February JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

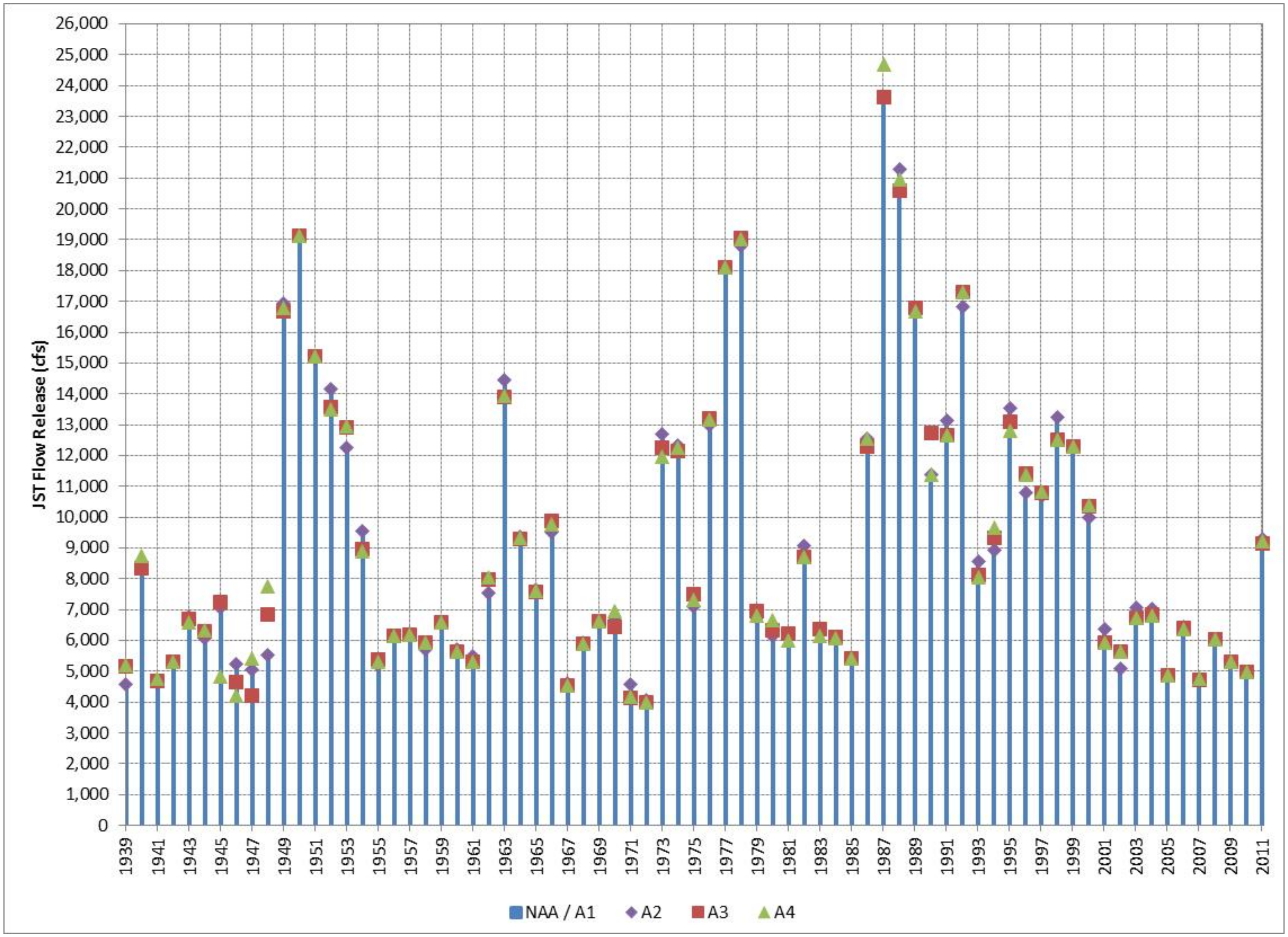


Figure 4.4-8 Mean March JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

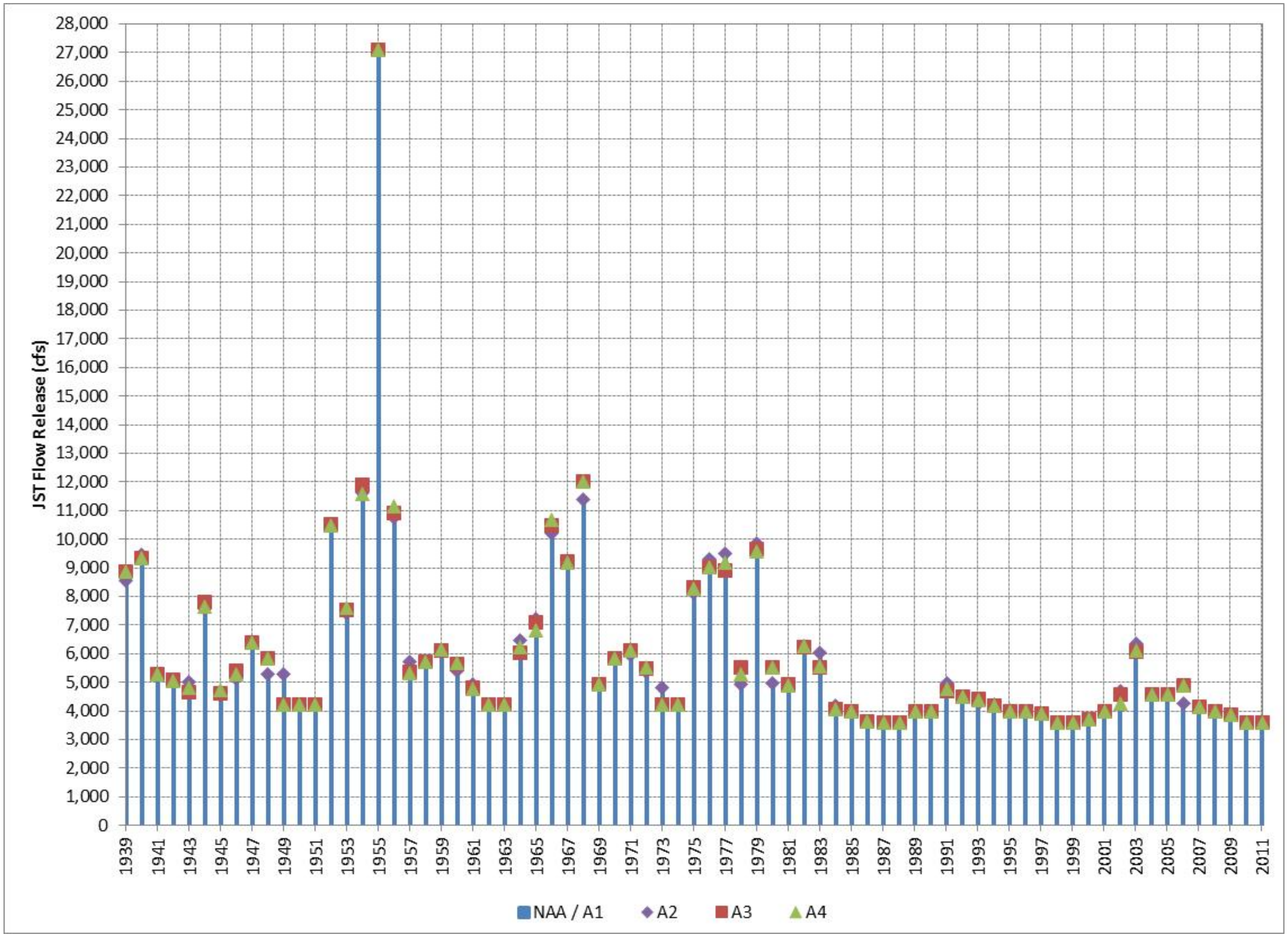


Figure 4.4-9 Mean April JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

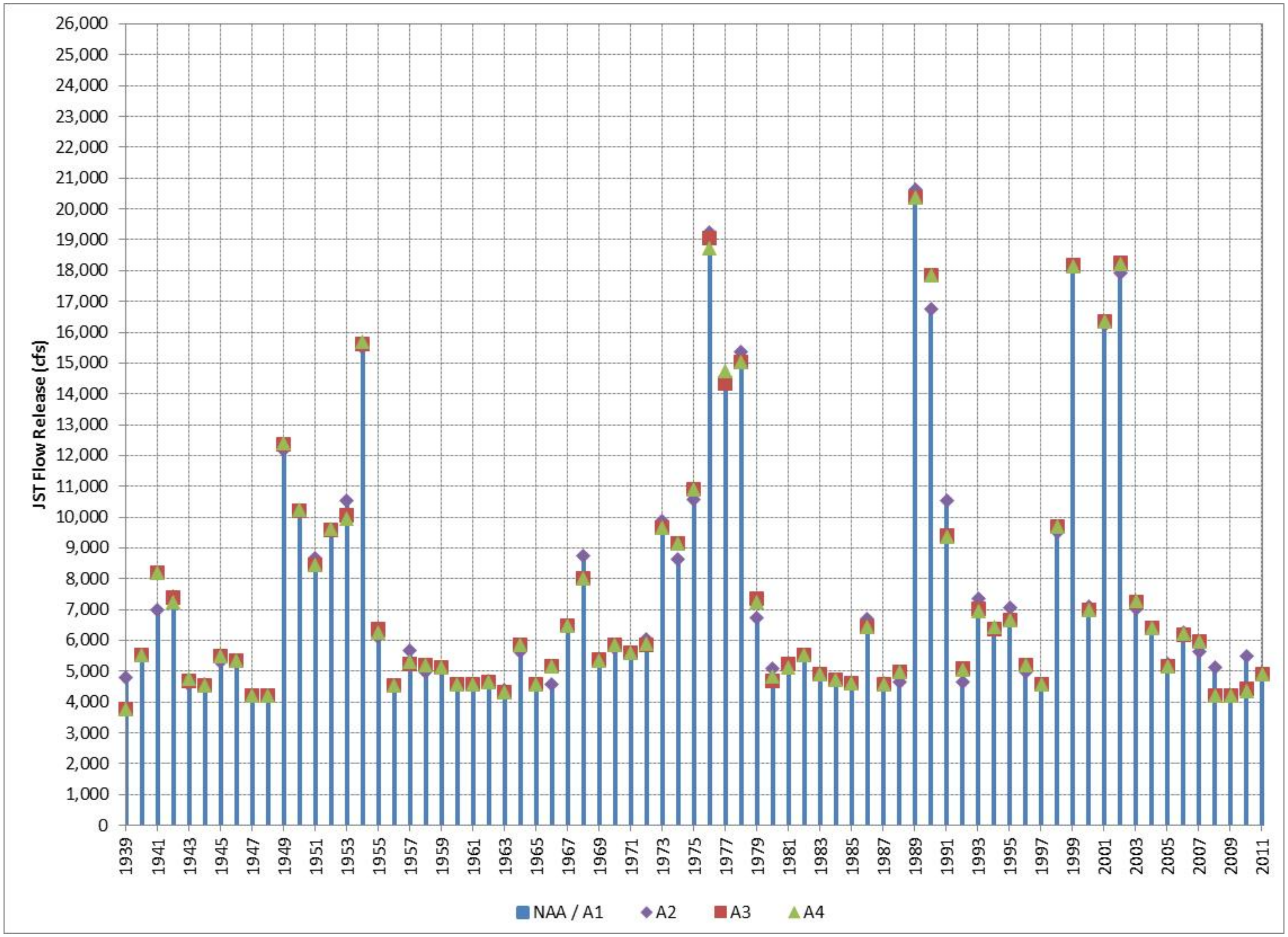


Figure 4.4-10 Mean May JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

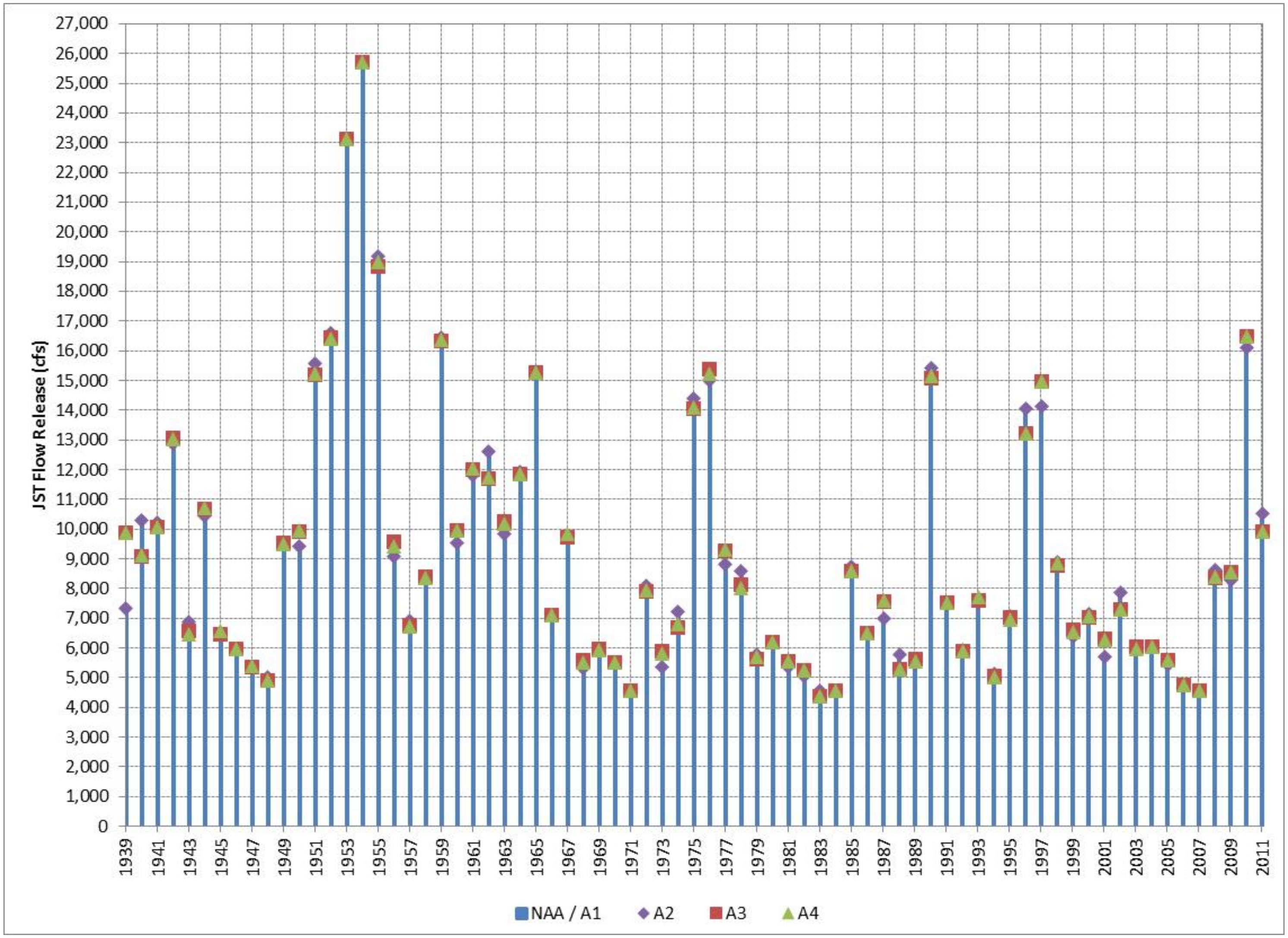


Figure 4.4-11 Mean June JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

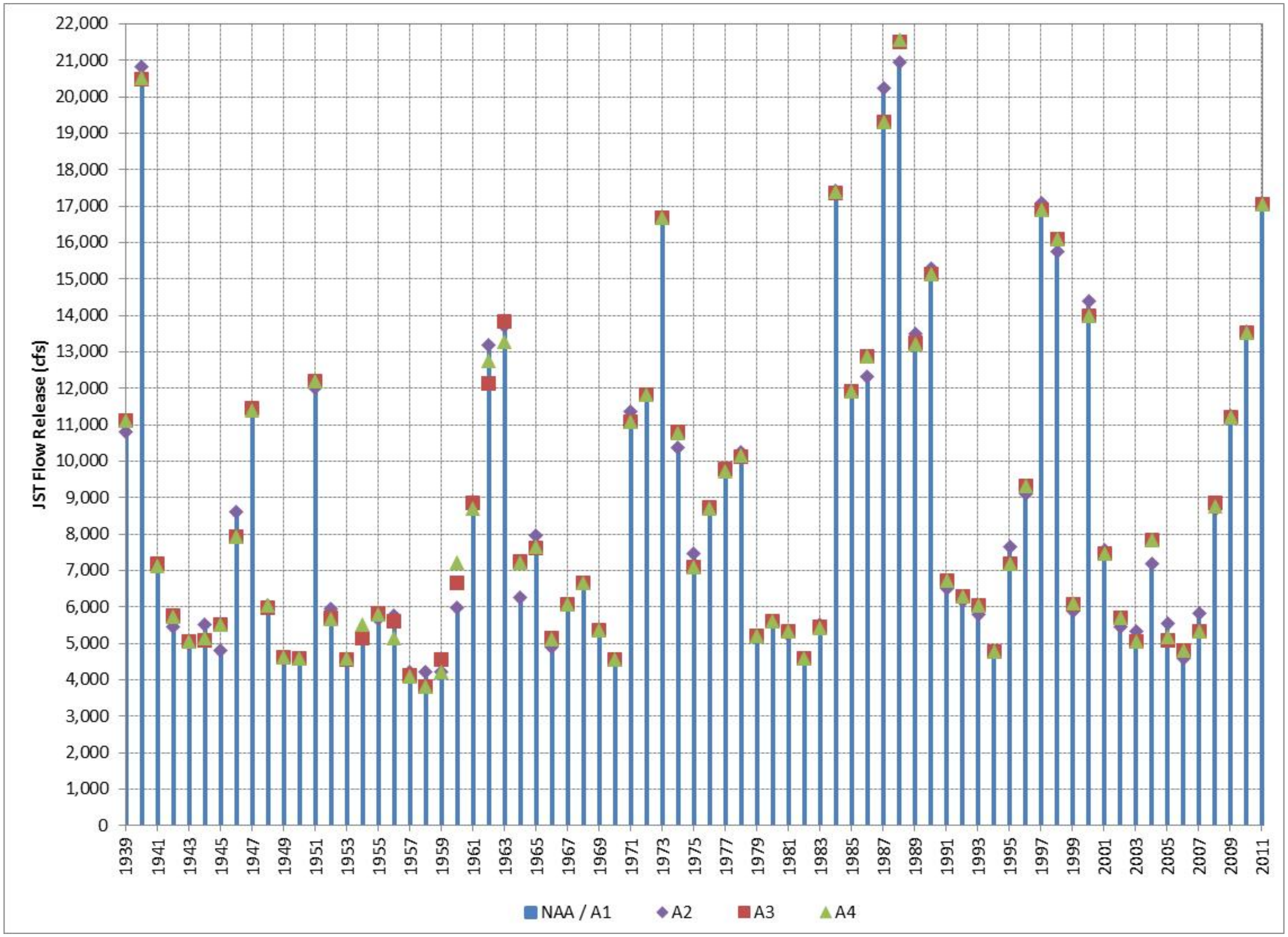


Figure 4.4-12 Mean July JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

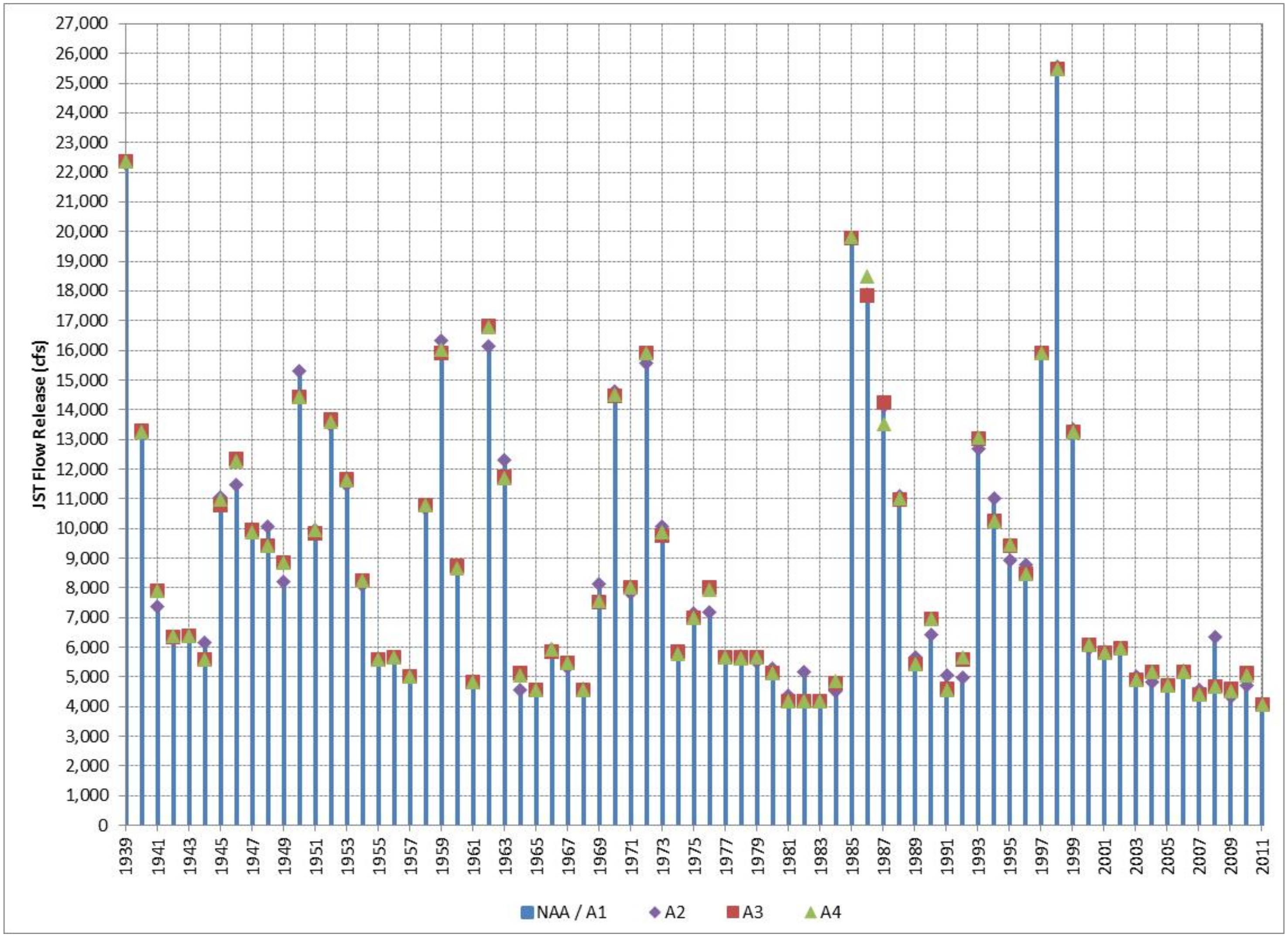


Figure 4.4-13 Mean August JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

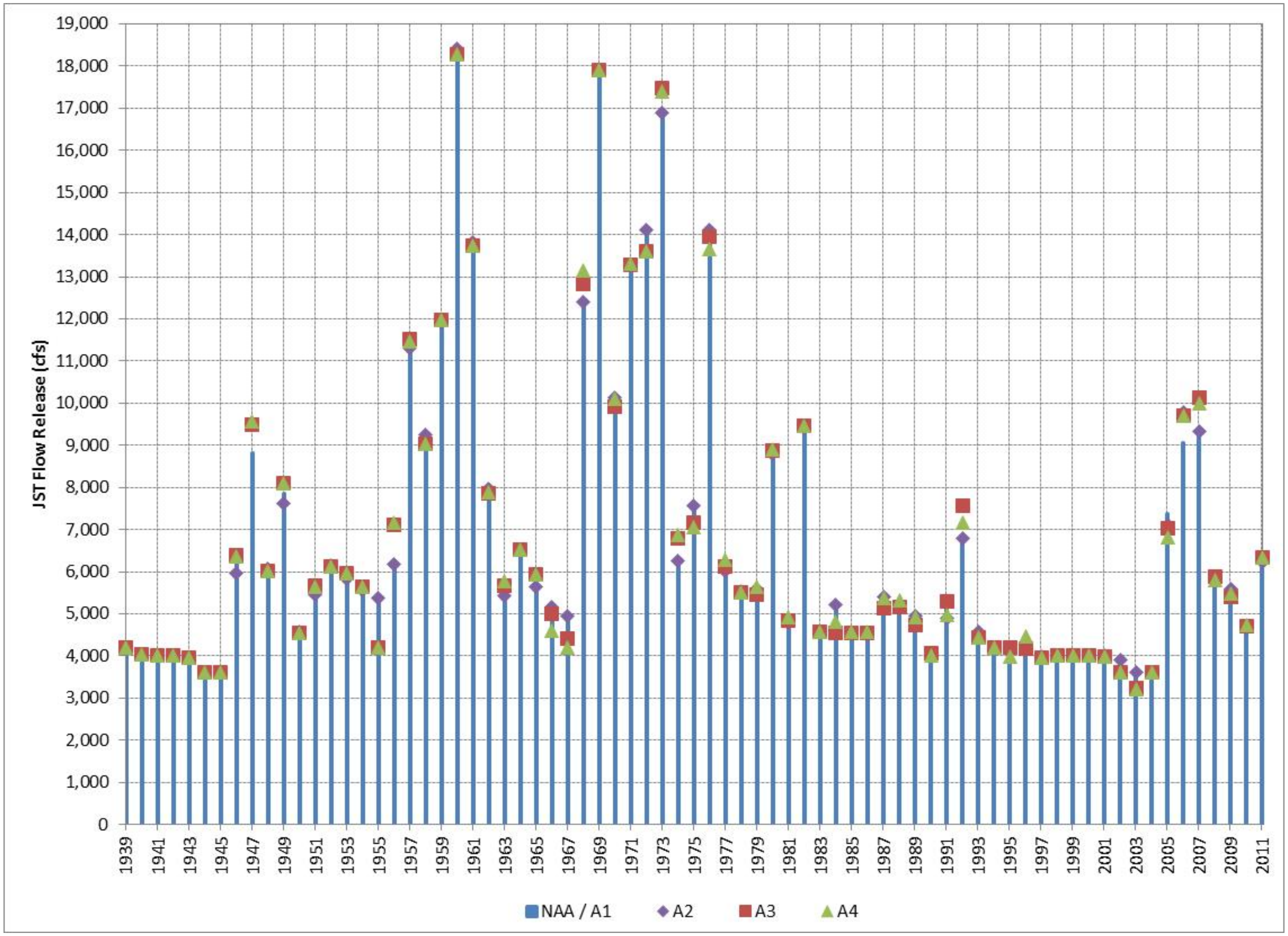


Figure 4.4-14 Mean September JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

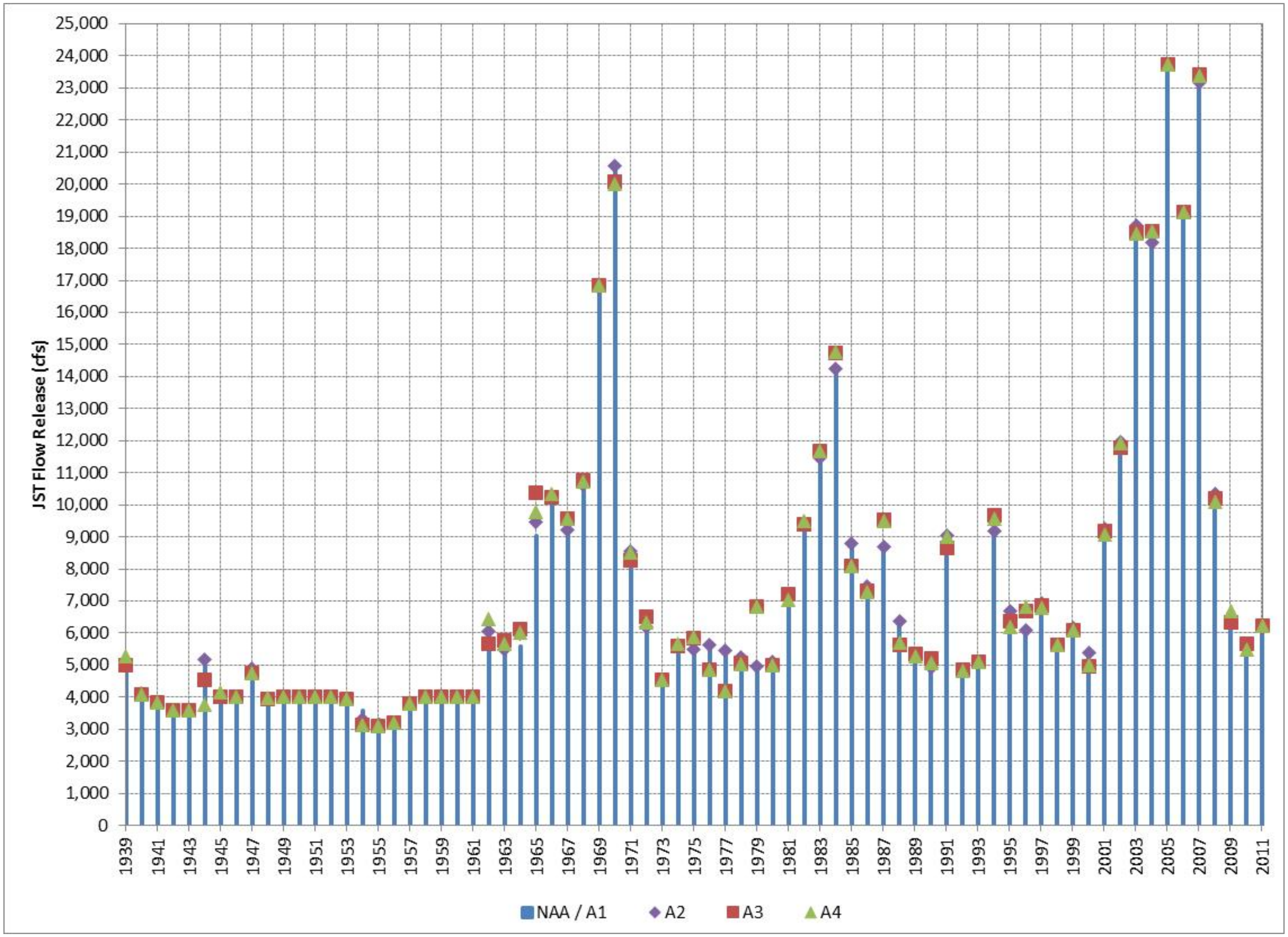


Figure 4.4-15 Mean October JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

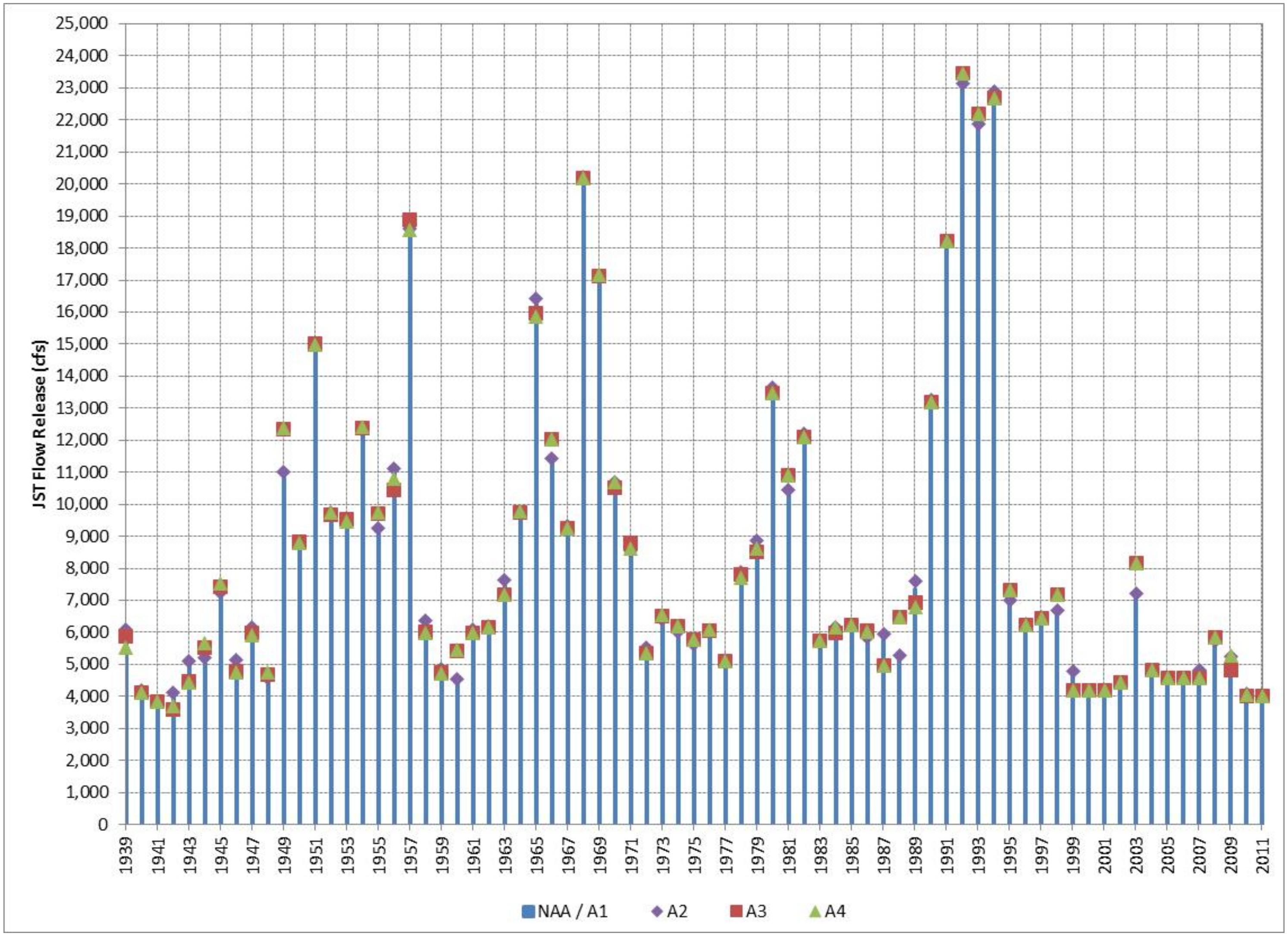


Figure 4.4-16 Mean November JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)

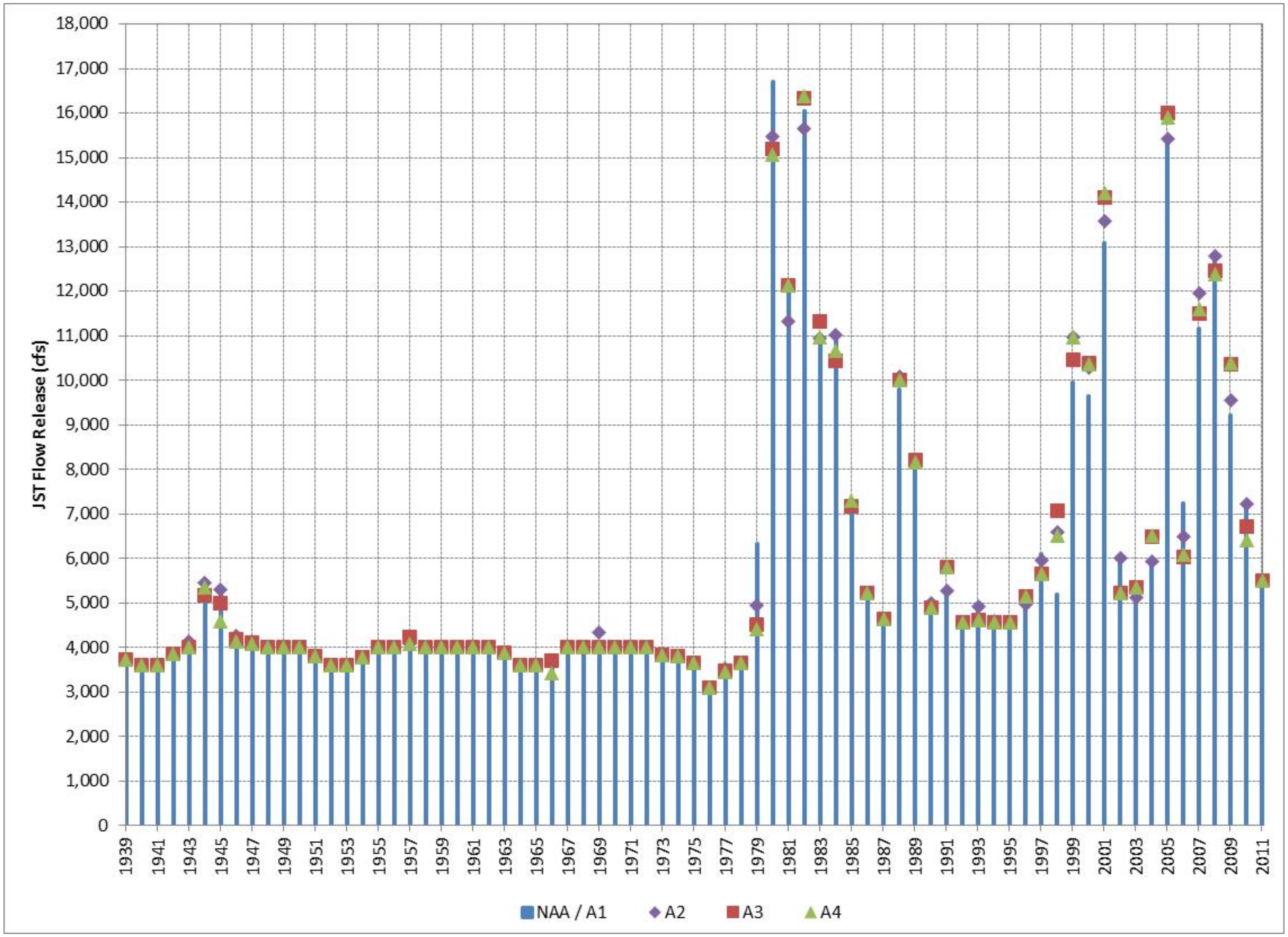
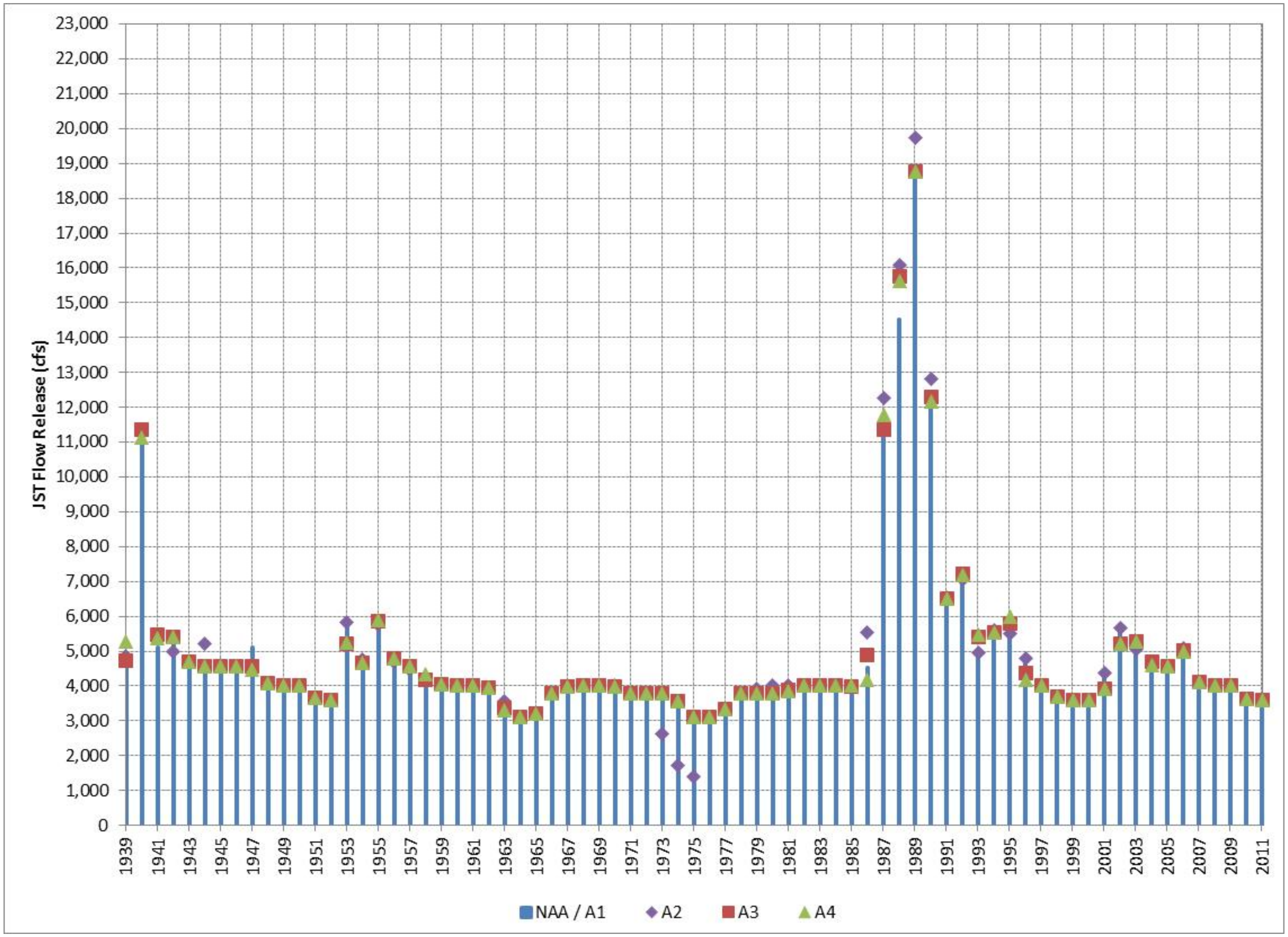


Figure 4.4-17 Mean December JST Lake Flow Release (Future Water Withdrawals with Historic Hydrology)



4.4.1.8 *Rare, Threatened, Endangered Fish and Mussel Habitats*

No federally-protected endangered or threatened fish or mussel species occur in Savannah River impoundments. The redeye bass and blackbanded darter, both of which are considered rare in South Carolina, have been collected in the Duke Energy reservoirs. No state-listed species occur in the USACE reservoirs. As mentioned in Section 2.9.5, there are several federally-listed fish species, including those classified as endangered, threatened, species of concern, or candidates for listing that occur in the lower Savannah River below JST. These include the shortnose sturgeon, Atlantic sturgeon, American eel, robust redhorse, bluebarred pygmy sunfish, and blueback herring. Three mussel species recently collected in the lower Savannah River (the Atlantic pigtoe, Savannah lilliput, and yellow lampmussel) are considered federal species of concern. The Altamaha arc-mussel and brother spike are two other federal species of concern. Blueback herring is an important forage fish in the USACE reservoirs. Varying lake elevations from year to year could shift the location of preferred habitat in each reservoir, which could result in a smaller volume of preferred habitat. However, because the differences in reservoir elevation between alternatives are small, it is expected that all four alternatives would have similar effects on the amount of preferred habitat for herring in each reservoir. Sufficient river flows during fish spawning runs, larval drift and juvenile outmigration, and overwintering are important for the completion of diadromous and resident fish life cycles. Summer low flow periods, particularly during drought years can reduce wetted perimeters and limit in-stream habitats. These periods can create stressful conditions for rare fish and mussel species, and during extreme circumstances can result in fish and mussel mortalities.

Future Water Withdrawals with Historic Hydrology

Analysis of critical time periods for the rare fish species in the lower Savannah River are identified in Section 4.4.1 and further discussed in Section 4.4.1.7. As discussed, small differences in mean monthly flows between alternatives occur infrequently. In addition, USACE will continue to release flows from JST dam in accordance with the USACE Drought Contingency Plan, which specifies the discharge rate for each drought level. As a result, the effects of all alternatives on rare lower Savannah River fish and mussel populations are expected to be minimal.

Model Sensitivity Analysis

Appendix O provides the HEC-ResSim model sensitivity analysis for monthly mean flow releases to the lower Savannah River. The same analysis and conclusions included in Section 4.4.1.7 also apply to the rare fish and mussel species in the lower Savannah River. Differences between alternatives are generally minor. Therefore, the effects of all alternatives on rare fish and mussel species in the lower Savannah River are expected to be minimal.

4.4.2 *Aquatic Plants*

Reservoir elevation model results (Sections 3.4 and 3.5) were reviewed to determine potential impacts to submerged aquatic vegetation (SAV) in the Duke Energy and USACE reservoirs and the lower Savannah River. SAV is occurs in the littoral zone, or upper 10 feet of a reservoir, with a primary growing season from March 1 to October 31 (the average date of the first killing frost to the last killing frost), with a peak growing season of typically May through September.

4.4.2.1 *Duke Energy Reservoirs*

Although Lake Jocassee has the largest pool drawdowns and largest differences between alternatives (as described in Section 3.4), little to no SAV occurs in Lake Jocassee and it is not considered a vital source of cover for littoral zone fishes (Rodriguez 2009). As a result, regardless of the alternative or model setup assumptions, no negative impacts to SAV are anticipated within Lake Jocassee.

The only SAV known to occur in Lake Keowee are hydrilla, parrot feather and coontail -- non-native invasive species. The hydrilla was chemically and manually treated until the infestation was eliminated. While there are small differences between NAA/A1, A2, A3, and A4 during droughts, similar to Lake Jocassee, no impacts to SAV in Lake Keowee are anticipated. This is also the case for the sensitivity analyses.

4.4.2.2 *USACE Reservoirs*

For the future water withdrawals with historic hydrology model runs, reservoir elevations for all four alternatives for Hartwell and RBR Reservoirs are similar and no effects on SAV during the growing season are expected. Invasive SAV, such as hydrilla, have not become abundant in

Hartwell and RBR Lakes. Brazilian waterweed, an invasive plant, is present in RBR, but it has not reached nuisance levels requiring treatment. Hydrilla is abundant in JST and USACE monitors its presence and treats infestations. While droughts may help in the overall control of hydrilla in JST by drying it out, differences between the four alternatives are not likely to impact the hydrilla population.

Similar to the future water withdrawals with historic hydrology model runs, differences in USACE reservoir elevations for the model sensitivity runs are minimal and not expected to affect SAV in Hartwell, RBR, or JST Reservoirs.

4.4.2.3 *Lower Savannah River Basin*

As described in Section 3.7, differences in flows released from JST are small and only occur during droughts. The effects of all four alternatives on lower Savannah River Basin SAV populations are expected to be similar.

4.4.3 ***Wetlands***

Detailed descriptions of the wetland communities in the Savannah River reservoirs and the mainstem Savannah River downstream from JST Lake are provided in Section 2.9. Wetlands contribute to the overall health of the environment by providing important functions such as floodwater and stormwater detention, nutrient cycling, exporting organic carbons, maintaining plant communities, and providing fish and wildlife habitats (USDA 2005). Wetland functions for reservoir-dependent, or fringe, wetlands and open water areas could decrease due to the lowering of the adjacent water table. In addition, disturbances to the dynamics of water movement and volume in a wetland can change the distribution and richness of plant species (Duke Energy 2005).

Reservoir elevation model results (Sections 3.4 and 3.5) were reviewed to identify potential impacts to palustrine emergent or fringe wetland communities in the Duke Energy and USACE reservoirs and lower Savannah River. Fringe wetlands are considered to occur in the upper 10 feet of the reservoir, with a primary growing season from March 1 to October 31 (the average date of the first killing frost to the last killing frost), and with a peak growing season of May through September.

4.4.3.1 *Duke Energy Reservoirs*

Future Water Withdrawals with Historic Hydrology

During most years, Duke Energy reservoirs are at or near (i.e., within 2 feet of) full pool during the peak growing season for all four alternatives, which supports overall wetland productivity. Impacts to fringe wetlands primarily occur during droughts when low lake elevations reduce the water table's connectivity to these habitats. During extreme droughts, all four reservoir operating scenarios result in elevations below the upper 10 feet for both Lakes Jocassee and Keowee (see Section 3.5.1, Figures 3.5-1 and 3.5-2). At these relatively low reservoir elevations, fringe wetlands would be similarly impacted regardless of the overall magnitude of the drawdown.

Differences between alternatives when reservoir elevations are in the upper 10 feet of their operating range are also of interest. For example, during the moderate drought that extended from 1997 to 1999, A3 and A4 maintain higher overall Lake Jocassee reservoir elevations than NAA/A1 and A2. Droughts resulting in moderate reservoir drawdowns (i.e., < 10 feet) have occurred approximately 14 years (i.e., 1941, 1942, 1945, 1946, 1954, 1959, 1963, 1978, 1980, 1983, 1991, 1997, 1998, and 1999) over the 73-year POR. During each of these years, A3 resulted in higher Jocassee reservoir elevations -- and would have had a smaller effect on wetlands -- than the other three alternatives.

Model results show Lake Keowee may experience drawdowns close to 10 feet during extreme droughts, which could potentially impact fringe wetlands under all alternatives. A3 and A4 typically result in higher overall reservoir elevations compared to the other alternatives and (approximately 1 – 2 feet higher than NAA/A1 and A2). Overall, A3 and A4 would result in fewer impacts to fringe wetlands than NAA/ A1 and A2. However, any impacts to fringe wetlands based on differences between alternatives would likely be minimal and short-term.

Model Sensitivity Analyses

Modeling current water withdrawals results in similar overall lake elevations within the upper 10 feet of each reservoir compared to future water withdrawals model scenarios. As a result, no incremental impacts are anticipated during the growing season. The only differences occur during extreme droughts (> 10 foot drawdowns) when differences between scenarios are not meaningful from a fringe wetland perspective.

The climate change scenario (instead of historic hydrologic conditions) results in reservoir elevations near full pool during the growing season most years in both Duke Energy reservoirs. There would be a lower frequency of moderate droughts, which cause both reservoirs to experience drawdowns up to 10 feet (approximately 12 years[8] over the 73-year POR, or roughly 16 percent of the time). A3 and A4 result in higher reservoir elevations (compared to NAA/A1 and A2) during these droughts, which could benefit wetland functions during these events. See Appendix M for detailed results.

4.4.3.2 *USACE Reservoirs*

Future Water Withdrawals with Historic Hydrology

Similar to the Duke Energy reservoirs, USACE reservoirs would generally be at or near (i.e., within 2 feet of) full pool during the peak growing season in all four alternatives, which supports overall wetland productivity. As described in Section 3.6, results for all four alternatives for the USACE reservoirs are almost identical over the entire modeled period. Therefore, no impacts to wetlands are likely during the growing season for any of the four modeled scenarios.

Model Sensitivity Analyses

For Hartwell, RBR, and JST Reservoirs, modeling current water withdrawals results in only minor changes to reservoir elevations within the upper 10 feet of each reservoir. As a result, no effects on wetlands are anticipated for the USACE reservoirs.

[8] For this comparison, drought events included Years 1939, 1940, 1941, 1945, 1946, 1959, 1963, 1978, 1981, 1983, 1998, and 1999.

Modeling climate change hydrologic conditions results in less than 0.35 feet differences (as described in Section 3.6) between modeled scenarios, which are not likely to result in any additional impacts to wetland productivity. See Appendix M for detailed results.

4.4.3.3 *Lower Savannah River Basin*

As described in Sections 3.7 and 4.1.1.7, relatively minor, infrequent differences occur between scenarios in monthly mean flows released downstream from JST. These small differences could create short-term differences in wetted perimeter and wetland connectivity. However, they are not expected to have long-term consequences on lower Savannah River wetland communities.

4.4.4 ***Wildlife***

Potential impacts to wildlife were reviewed for each reservoir based on the HEC-ResSim model results. This evaluation focused on identifying differences between alternatives affecting habitat (i.e., nest cover) and food sources associated with lowering reservoir elevations. The analysis included both the full POR and the reproductive season of March 1 through July 31 (i.e., breeding period until the young are fledged or weaned).

4.4.4.1 *Duke Energy Reservoirs*

Future Water Withdrawals with Historic Hydrology

During most years, Duke Energy reservoirs are at or near (i.e., within 2 feet of) full pool during the breeding season for all four alternatives, which supports wildlife productivity by creating habitat for nesting and foraging activities. Average differences in daily reservoir elevation between the four alternatives are relatively small, averaging 2.17 and 0.90 feet for Lakes Jocassee and Keowee, respectively (Section 3.5). For the Duke Energy Reservoirs, A3 and A4 generally result in higher reservoir elevations compared to NAA/A1 and A2 (see Section 3.5.1, Figures 3.5-1 and 3.5-2). For Lake Keowee, the only exception is during extreme droughts (i.e., near the end of 2008) when A2 results in higher elevations than A3 and A4.

Overall, for both Lakes Jocassee and Keowee, A3 and A4 would provide a small benefit compared to NAA/A1 and A2 during wildlife breeding seasons, given the higher reservoir elevations.

Model Sensitivity Analyses

As previously discussed in Section 3.5, modeling current water withdrawals results in higher reservoir elevations, with small differences between the four alternatives.

Modeling climate change hydrologic conditions results in Duke Energy reservoir elevations at or near full pool during the breeding season. As expected, differences between scenarios are larger than when using historic hydrology. A3 and A4 result in higher reservoir elevations (compared to NAA/A1 and A2), which would benefit wildlife habitat during droughts. See Appendix M for more detailed model sensitivity analyses results.

4.4.4.2 *USACE Reservoirs*

Similar to the Duke Energy reservoirs, the USACE reservoirs are generally at or near (i.e., within 2 feet of) full pool during the peak breeding season for all four alternatives, which supports wildlife productivity. Differences in reservoir elevations between the four alternatives are relatively minor, with an average daily difference of 0.37 feet at Hartwell, 0.35 feet at RBR, and 0.30 feet at JST (see Section 3.6). Since there are only minor differences in reservoir elevations between operating scenarios, the effects on wildlife habitat or breeding around the USACE reservoirs are expected to be similar.

Model Sensitivity Analyses

Modeling current water withdrawals or assuming climate change hydrologic conditions, does not result in USACE reservoir elevation differences that negatively impact the breeding season. Therefore, the effects of all four alternatives on wildlife around the USACE reservoirs are expected to be similar. See Appendix M for detailed results.

4.4.4.3 *Lower Savannah River Basin*

As described in Section 3.7, relatively minor, infrequent differences occur between alternatives for monthly mean flows released from JST. Monthly mean flows (provided in Section 4.4.1.7) were also reviewed to evaluate potential impacts during the breeding season. While there are some small differences between alternatives in flows released from JST, impacts to nesting or foraging are expected to be similar for all four alternatives, would be short-term, and not expected to have long-term consequences on wildlife in the lower Savannah River.

4.4.5 *Protected Species*

As stated in Section 2.9.5 and Table 2.9-2, federally-listed threatened, endangered, proposed endangered, proposed threatened, and targeted federal species of concern were reviewed and 12 species have the potential for impacts within the study area and include the bald eagle, manatee, wood stork, shoals spider-lily, shortnose sturgeon, Atlantic sturgeon, robust redhorse, American eel, yellow lampmussel, Savannah lilliput, the Atlantic pigtoe, and the bluebarred pygmy sunfish. As described in Section 3, Duke Energy and USACE reservoir elevation differences for the four alternatives are similar with their differences being evident during droughts. The differences in reservoir elevation are unlikely to affect the bald eagle due to its mobility and adaptability near the reservoirs. Flows released to the lower Savannah River from JST also exhibit only minor differences in timing and duration between alternatives. As a result, it is unlikely differences in alternatives would affect manatee, wood stork, or shoals spider-lily habitat. In addition, flows released downstream of JST would generally not drop below 3,100 cfs regardless of alternative, which provides baseline habitat for aquatic and terrestrial species in the lower Savannah River reach. The remaining species listed are fish and mussels; potential impacts to fish and mussels were previously addressed in Section 4.4.1.8.

4.4.6 *Special Biological Issues*

Lake Jocassee is surrounded by SC DNR's James Timmerman Natural Resources Area at the Jocassee Gorges (Jocassee Gorges) and other natural areas. The primary objectives for the Jocassee Gorges are to maintain the natural character of the area and maintain and restore or enhance noteworthy plant, fish, and wildlife communities and their habitats (there are 171 known occurrences of rare, threatened, or endangered species over 32,000 acres) (SC DNR 2010b). Since the Jocassee Gorges is not directly affected by the water fluctuations of the reservoir, none of the alternatives are expected to adversely impact natural areas within the region.

As described in Section 3.7, flows released downstream of JST are similar between the four alternatives since USACE will continue to follow its 2012 Drought Plan. Since the USACE reservoir system would be in drought for a longer period with the four alternatives (described in Section 4.3.4), the Corps would implement the smaller releases from JST Dam for longer periods. Wetlands and wildlife at the Savannah National Wildlife Refuge would experience low river flows during droughts for longer durations. This would extend the adverse effects of a drought on those resources over a longer period of time.

As described in Section 2.9.6, EFH exists in the Savannah River from its mouth to just upstream of the Houlihan Bridge. This includes estuarine areas and habitat for species for which Management Plans have been prepared by the South Atlantic Fishery Management Council. Potential influences to these areas from JST flow releases include salinity levels and saltwater intrusion. Oligohaline areas (< 8 ppt of salinity) would be most affected by reductions in river flow and greater intrusion of saltwater. Continuous recording water quality gages operate in the Savannah River estuary. When requested by state natural resource agencies, USACE may perform additional monitoring during severe droughts to better define the extent of the salinity intrusion. Average JST flow releases (April through December) for each of the 51 years which would trigger the USACE 2012 Drought Plan are provided in Tables 3.7-1 and 3.7-2. Differences between A3 and A4, compared to NAA/A1, are less than 5 percent on an annual basis. Instances where A3 and A4 flow releases are less than NAA/A1 flow releases tend to occur during less severe droughts (i.e., 1962 and 1993) when average flows are well above 4,200 cfs. As a result, the effects of all four alternatives on EFH in the Savannah River estuary are expected to be similar.

HEC-ResSim model sensitivity analyses results using current water withdrawals or climate change hydrology are similar to flow releases from JST using future water withdrawals and historical hydrology. Differences in average flow releases between scenarios for each sensitivity analyses are minor. As a result, the effects of all four alternatives sensitivity analyses on EFH in the Savannah River estuary are expected to be similar.

4.5 Socioeconomic Issues

4.5.1 *Economic Impact Analysis*

4.5.1.1 *Hartwell Lake Economic Impact Model and Analysis*

In November 2010, STI released a report entitled “An Economic Analysis of Low Water Levels in Hartwell Lake” (see Appendix P), which analyzed the effects of low water levels at the reservoir on the regional economy. The report, commissioned by USACE and the county governments adjacent to Hartwell Lake, examined the 21-month drought period from April 2007 to December 2008. During this period, reservoir elevations stayed well below the summer full pool elevation of 660 feet AMSL. Many in the region hypothesized this would have a measurable, negative impact on the economies of Franklin, Hart, Stephens, Anderson, Oconee, and Pickens Counties. Anecdotal evidence and a study focusing on the drought of 1998 also suggested the impact on the regional economy would be significant (STI. 2010).

The economic analysis was intended to identify whether changing water levels in Hartwell Lake have a measurable effect on the economy and property values in surrounding counties. The study examined selected reservoir, real estate, and economic data over an 11-year period from 1998 to 2009, which includes the two most extreme droughts on record (1999–2002 and 2007–2008).

Several statistical analysis techniques were combined to identify the strength of the relationship between lake elevations and economic activity in the surrounding counties. Standard statistical techniques were used to identify the relationships between reservoir elevations and real estate sales, property sales prices, and gross retail sales. Real estate data included the number of monthly transactions (including sales price and property attributes) on all parcels in the counties. Economic data included monthly gross retail sales in selected sectors plus other measures of the local and regional economy. Gross retail sales included, among others, retail trade, general merchandise, groceries, gas, boating stores, restaurants, sporting goods stores, bars, and liquor store sales. Economic and population data were collected from a variety of local, state, and federal government secondary source materials. These variables captured both resident and non-resident economic activity from people buying homes on the reservoir, purchasing goods and services on or near the reservoir, and visiting reservoir sites for recreation purposes.

The Regional Dynamics (REDYN) input-output model was then used to estimate the total economic impact of different Hartwell pool levels on the six-county region. The REDYN model produced estimates of the marginal changes in the value of goods and services in selected industry sectors as a result of changing reservoir levels. The model generates estimated economic impacts for four measures: (1) employment, (2) output, (3) disposable income, and (4) net government revenue.

Study results described economic impacts of reduced reservoir levels in Hartwell Lake as being negative and measurable. However, the reservoir is not a "primary economic driver" of the region. The total economic impact of lower reservoir elevations on the six-county region was determined to be less than one-tenth of one percent. To place the economic impact in context, the total economic output for the region during the study period was $30.2 billion, while the negative impact of the drought on output was estimated to be $18.8 million, a decline of 0.06 percent. Anderson County showed the largest decline at -0.16 percent followed by Franklin County (-0.07 percent), Hart County (-0.07 percent), and Pickens County (less than -0.01 percent). Both Stephens and Oconee Counties showed economic gains of 0.09 percent and 0.08 percent, respectively.

Three parameters were measured as indicators of economic movement: recreational use at the reservoir, real estate transactions around the reservoir, and the sale of reservoir-related goods and services (e.g., sporting goods, bars, boating stores, etc.). For every foot of pool elevation change, the number of monthly visitors to USACE recreational sites on Hartwell rose or fell by approximately 21,200. There were 56 fewer (3.4 percent) real estate transactions for parcels with reservoir access during the study period. The impact of the real estate decline was not distributed evenly throughout the six counties, but rather estimated lost transactions due to drought were a larger share of total activity in those counties with fewer total real estate transactions. The sale of retail goods and services showed variable correlations with reservoir elevations, depending on the sector. Sectors such as general merchandise, bars, boating stores, and sporting goods stores had a statistically significant relationship with reservoir elevations (STI. 2010).

The study showed that Oconee and Stephens Counties experienced positive economic growth during the study period. In the case of Oconee County, STI reports this may be the result of Lake Keowee being in direct competition with Hartwell as a recreation destination. Water levels at Lake Keowee are generally more stable, suggesting that as pool elevations decrease at Hartwell, recreational users tend to select Lake Keowee as an alternative destination. As for Stephens County, economic evidence suggests as reservoir-related activity slows down, other business sectors such as restaurants located away from the reservoir see increased activity.

4.5.1.2 *Application of Hartwell Lake Model to Daily Reservoir Levels*

In April 2014, STI ran the same economic model with the HEC-ResSim model output of daily reservoir elevations at Hartwell for each of the four alternatives to identify any regional economic impact of the alternatives on the six counties bordering the reservoir. Since the REDYN economic model only provides information dating back to 2001, the regional economic model simulations specific to the Hartwell Lake analysis cover the HEC-ResSim lake elevation results from 2001 to 2008. Economic modeling results were prepared for each operating scenario (NAA/A1, A2, A3, and A4) relative to differences from the summer conservation level, so forecasted changes in economic measures could be estimated.

Assuming future (i.e., Year 2066) water withdrawals with historical hydrology, Figure 4.5-1 depicts the forecasted economic effect of pool elevation changes in terms of overall dollar impact. Likewise, Figure 4.5-2 provides the forecasted impact on employment.

The STI analysis indicates that all four alternatives would produce similar economic and employment impacts around Hartwell Lake. Only minor differences were identified between the NAA and the other alternatives.

Figure 4.5-1 Hartwell Lake Economic Impacts (With Future Water Withdrawals and Historic Hydrology)

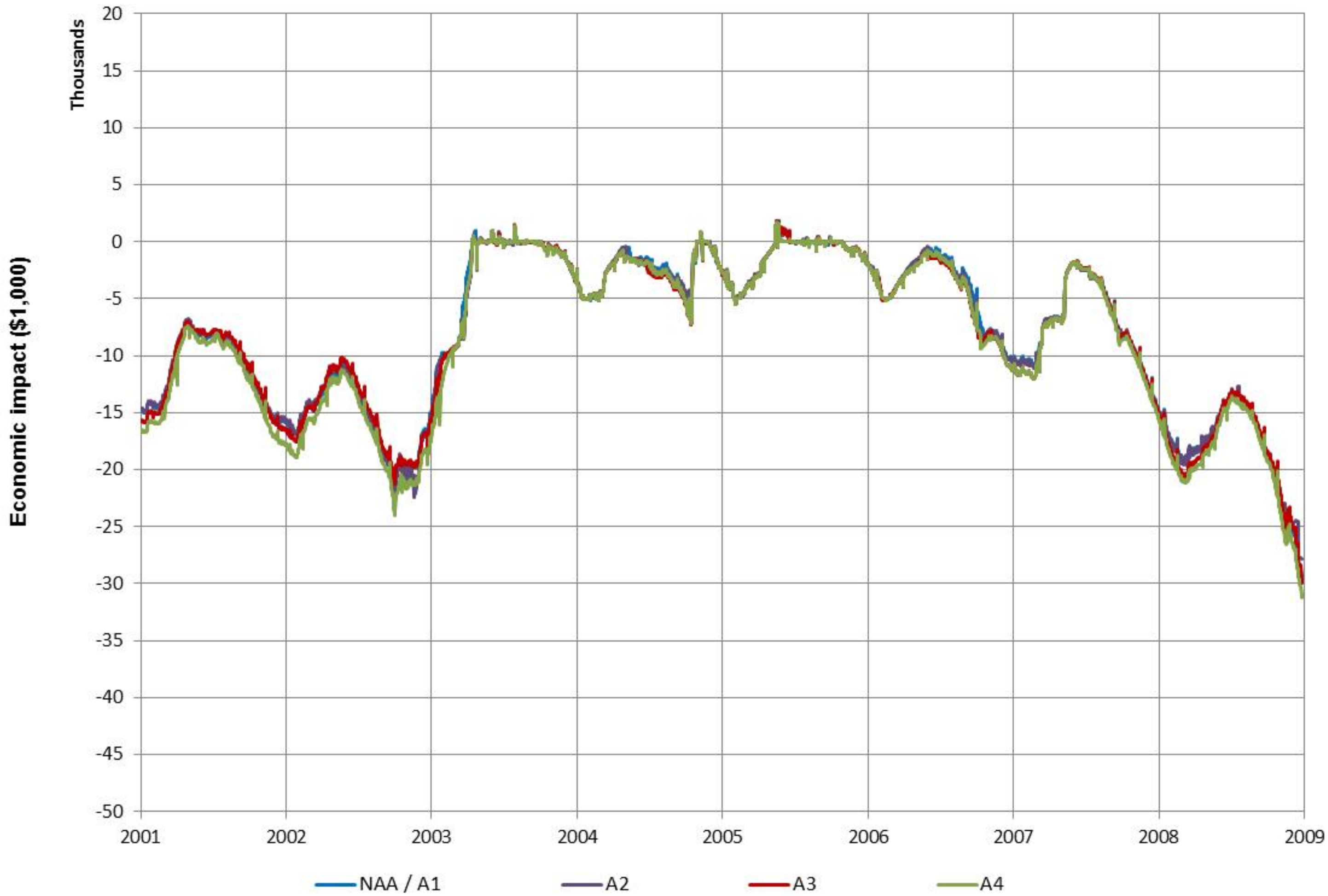
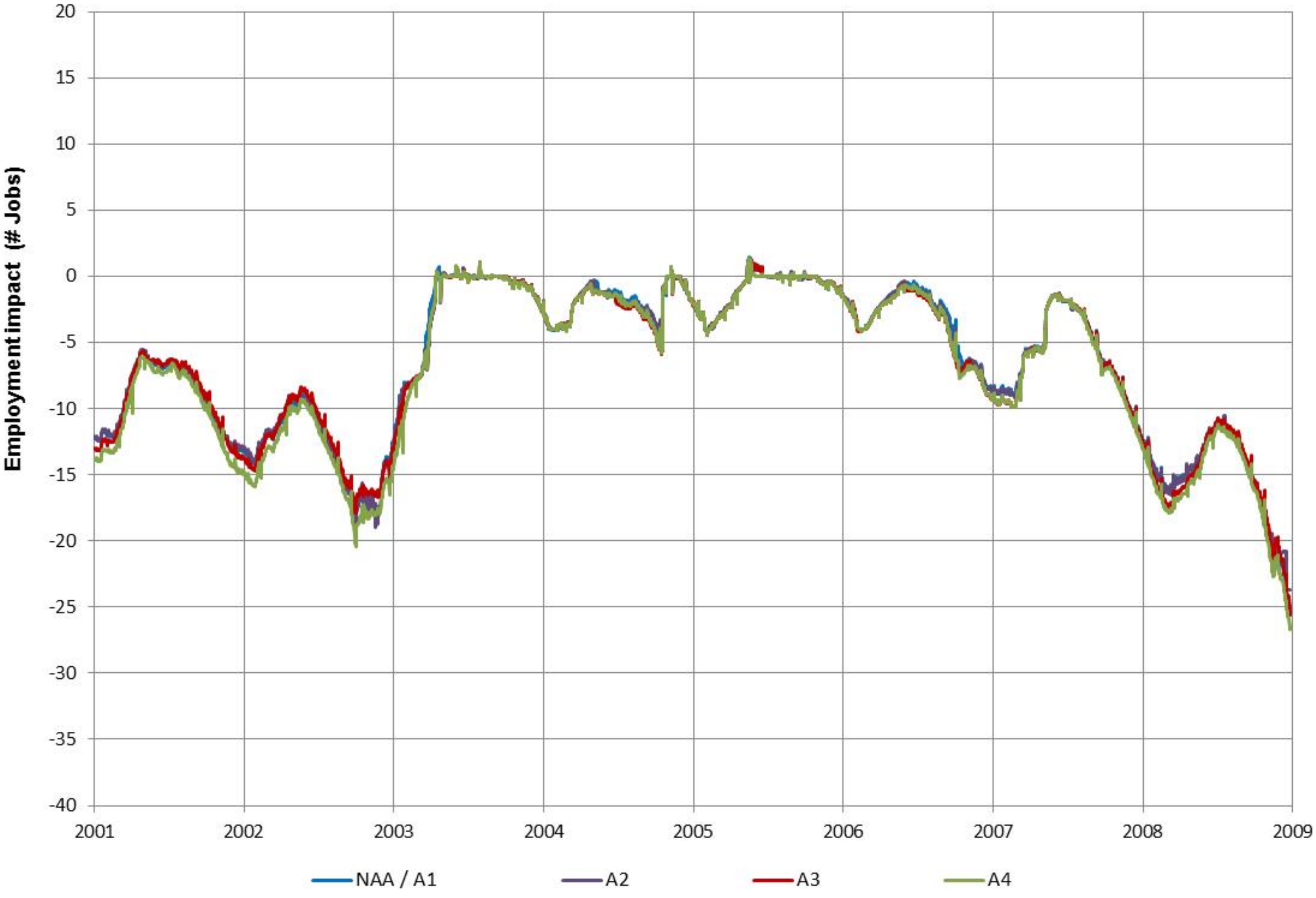


Figure 4.5-2 Hartwell Lake Employment Impacts (With Future Water Withdrawals and Historic Hydrology)



Model Sensitivity Analysis

Using current (i.e., Year 2010) water withdrawals results in smaller, yet similar economic impacts for all alternatives compared to future (i.e., Year 2066) water withdrawals. There would be no expected difference in output, disposable income, government revenue, or number of jobs regardless of reservoir operations. See Figures Q-1 and Q-2 in Appendix Q for detailed results.

Modeling climate change instead of historic hydrologic conditions results in larger economic and employment impacts. However, all four alternatives produce similar results. See Figures Q-3 and Q-4 in Appendix Q for detailed results.

4.5.1.3 *Application of Economic Impact Model to Lake Keowee Daily Reservoir Levels*

Subsequent to the RTI completing its study on Hartwell, it developed a similar economic model for Lake Keowee to examine the economic impacts of the four alternatives on counties (Oconee and Pickens) surrounding that lake (see Appendix R). Economic and employment impacts on Lake Keowee counties using the future water withdrawals with historical hydrology model assumptions are provided in Figures 4.5-3 and 4.5-4, respectively.

During the majority of the 2001-2008 modeling period, differences between alternatives are within $2,000 and 3 jobs of each other. The largest differences occurred near the end of 2008 during an extreme drought. As expected, NAA/A1 produces the largest economic impact as Lake Keowee's elevation drops to 782 feet AMSL. A2 results in the least economic impact for counties surrounding Lake Keowee because pool elevations are not allowed to drop below 794.6 feet AMSL. A3 and A4 results are similar to each other and fall between A2 and NAA/A1 results.

Figure 4.5-3 Lake Keowee Economic Impacts (With Future Water Withdrawals and Historic Hydrology)

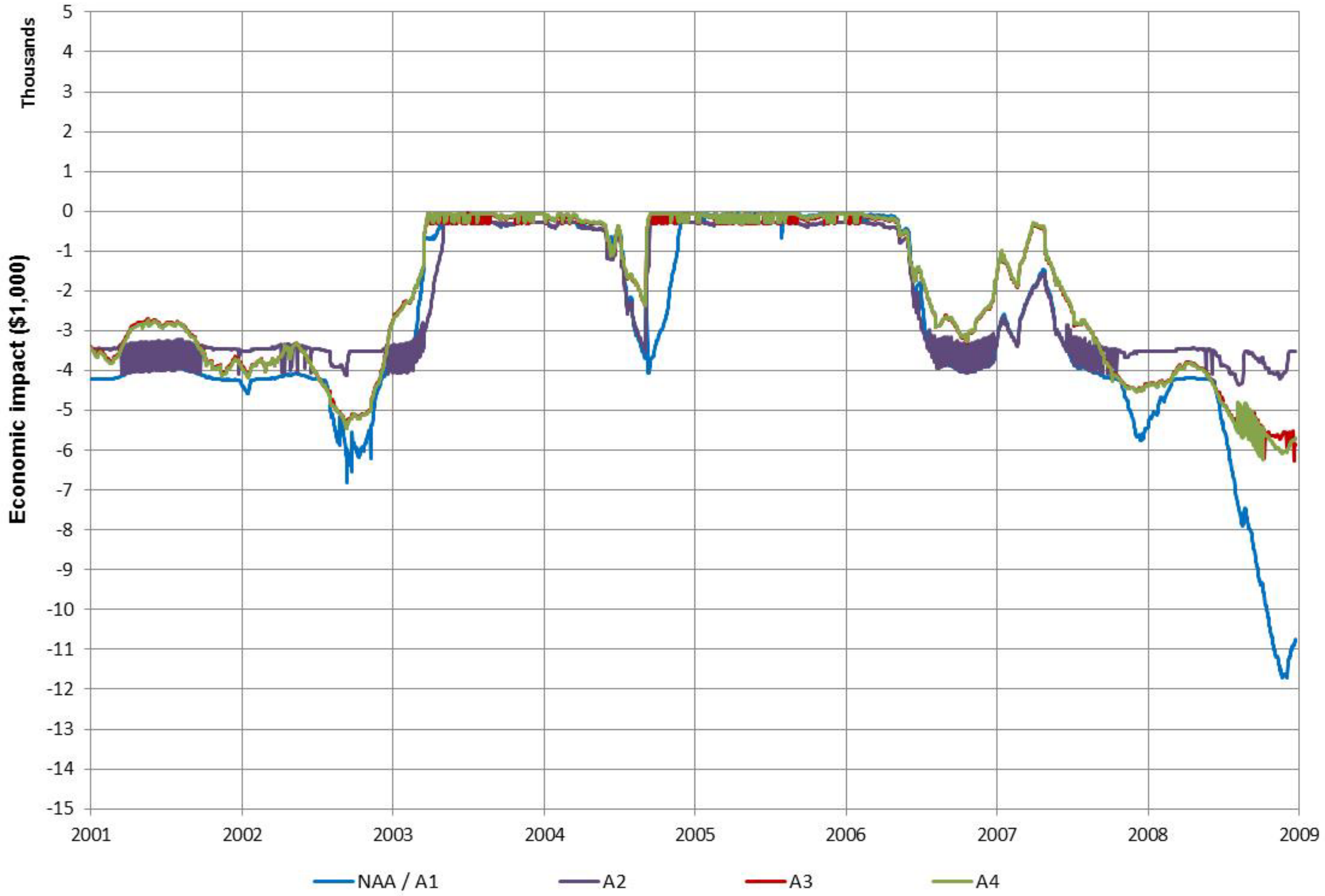
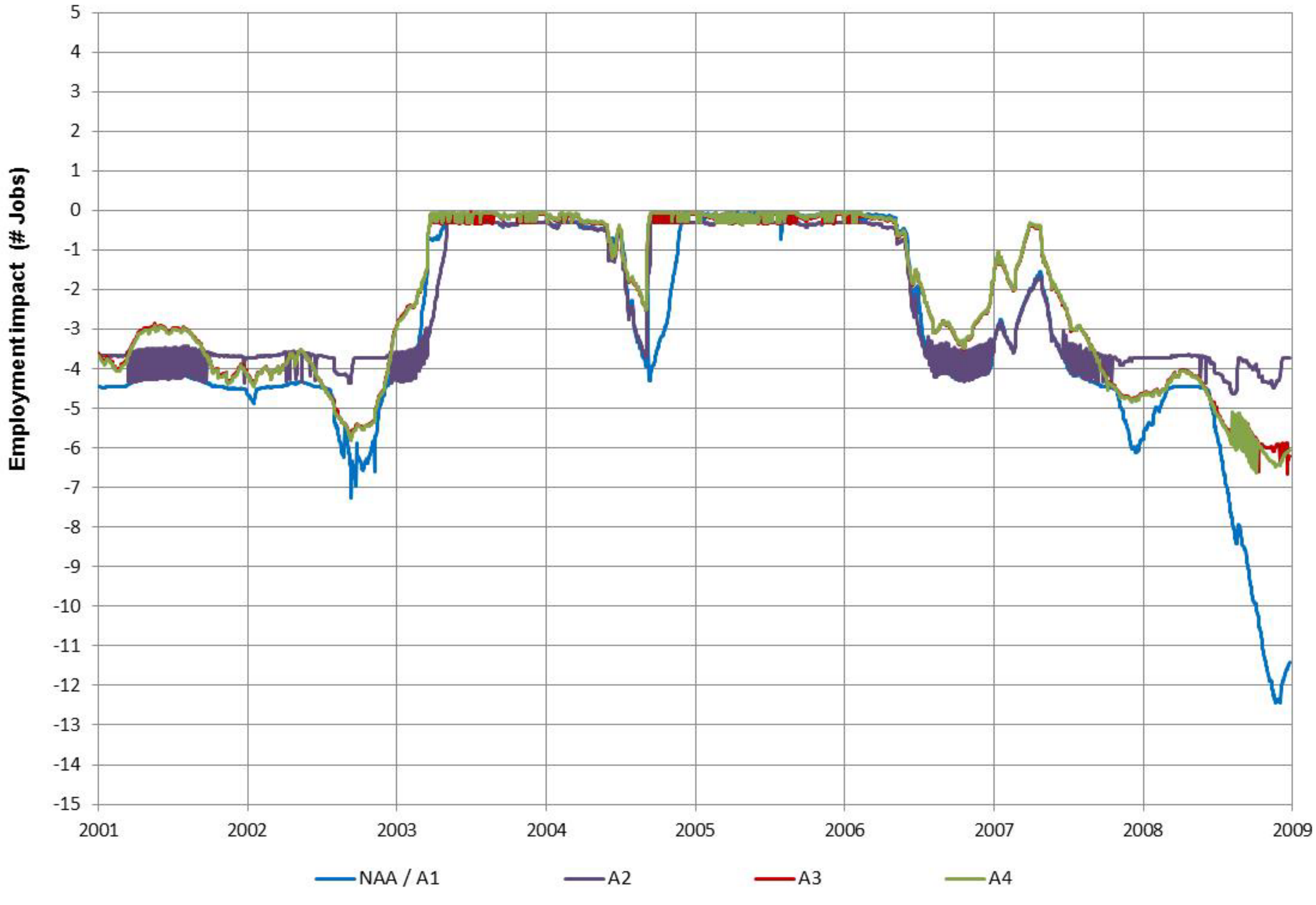


Figure 4.5-4 Lake Keowee Employment Impacts (With Future Water Withdrawals and Historic Hydrology)



Model Sensitivity Analysis

The magnitude of impacts to the regional economy from A2, A3, and A4 is similar when current water withdrawals are compared to future water withdrawals. The regional economic and employment model results are approximately 28 percent lower for NAA/A1 when using future water withdrawals with historic hydrology model results. See Figures Q-5 and Q-6 in Appendix Q for detailed results. That is a substantial difference that state water managers may want to consider as they make decisions in the future.

Using climate change hydrology instead of historic hydrologic conditions produces similar results from the economic model for all four alternatives. See Figures Q-7 and Q-8 in Appendix Q for detailed results.

4.5.1.4 *JST Reservoir Regional Economic Model*

During 2011, STI developed a regional economic model for JST Reservoir and its surrounding region (Appendix S). They drew upon the models they had previously developed for Hartwell and Lake Keowee to produce a model of the South Carolina and Georgia counties surrounding JST (McCormick, Columbia, Elbert, Lincoln, McDuffie, and Wilkes).

Economic and employment impacts on JST counties from the NAA and the four alternatives using the future water withdrawals with historical hydrology are provided in Figures 4.5-5 and 4.5-6, respectively.

During most of the modeled period (2001 – 2008), economic and employment impacts resulting from the four alternatives are almost identical (i.e., differences are less than $20,000 and fewer than 20 jobs between alternatives).

Figure 4.5-5 JST Lake Economic Impacts (With Future Water Withdrawals and Historic Hydrology)

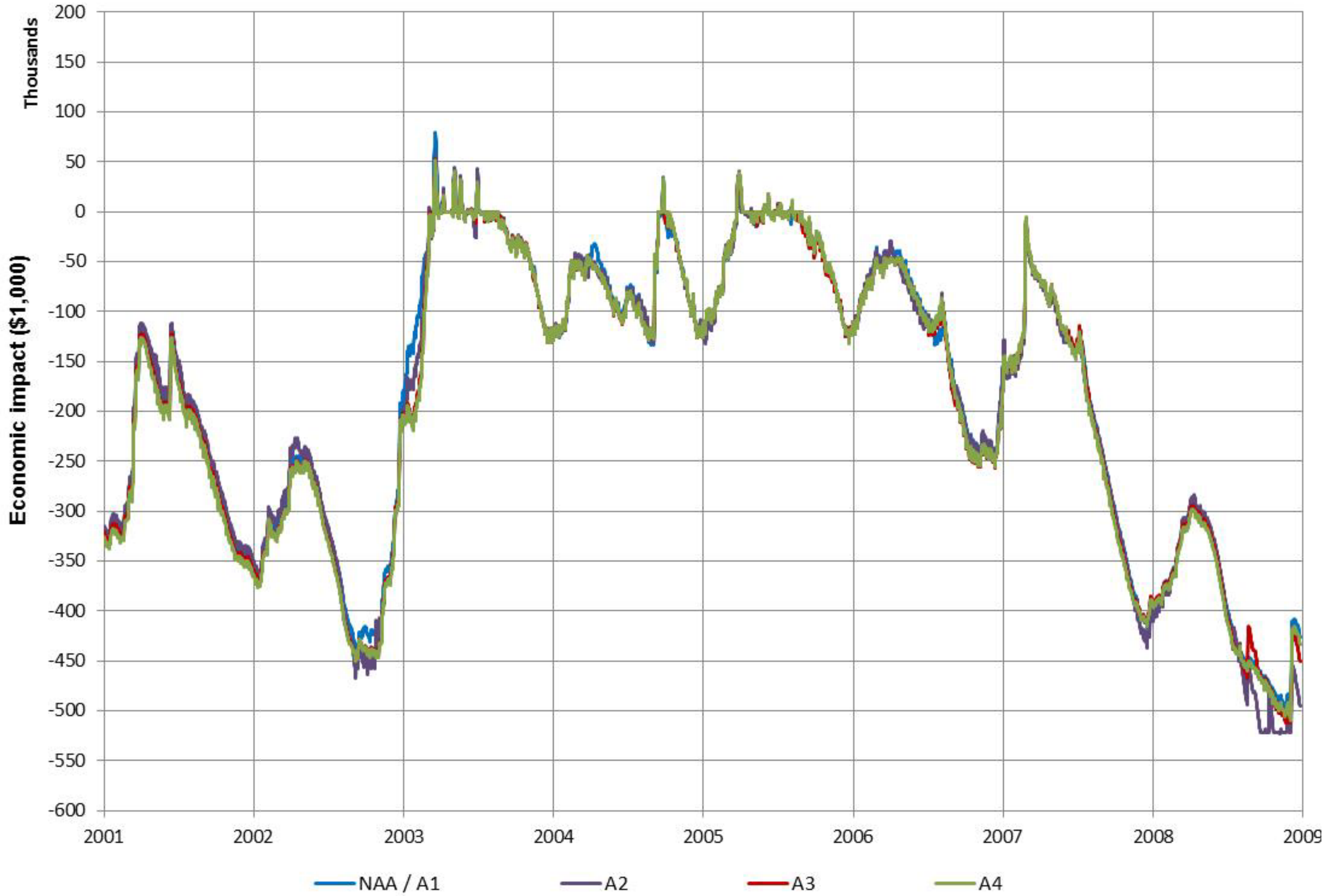
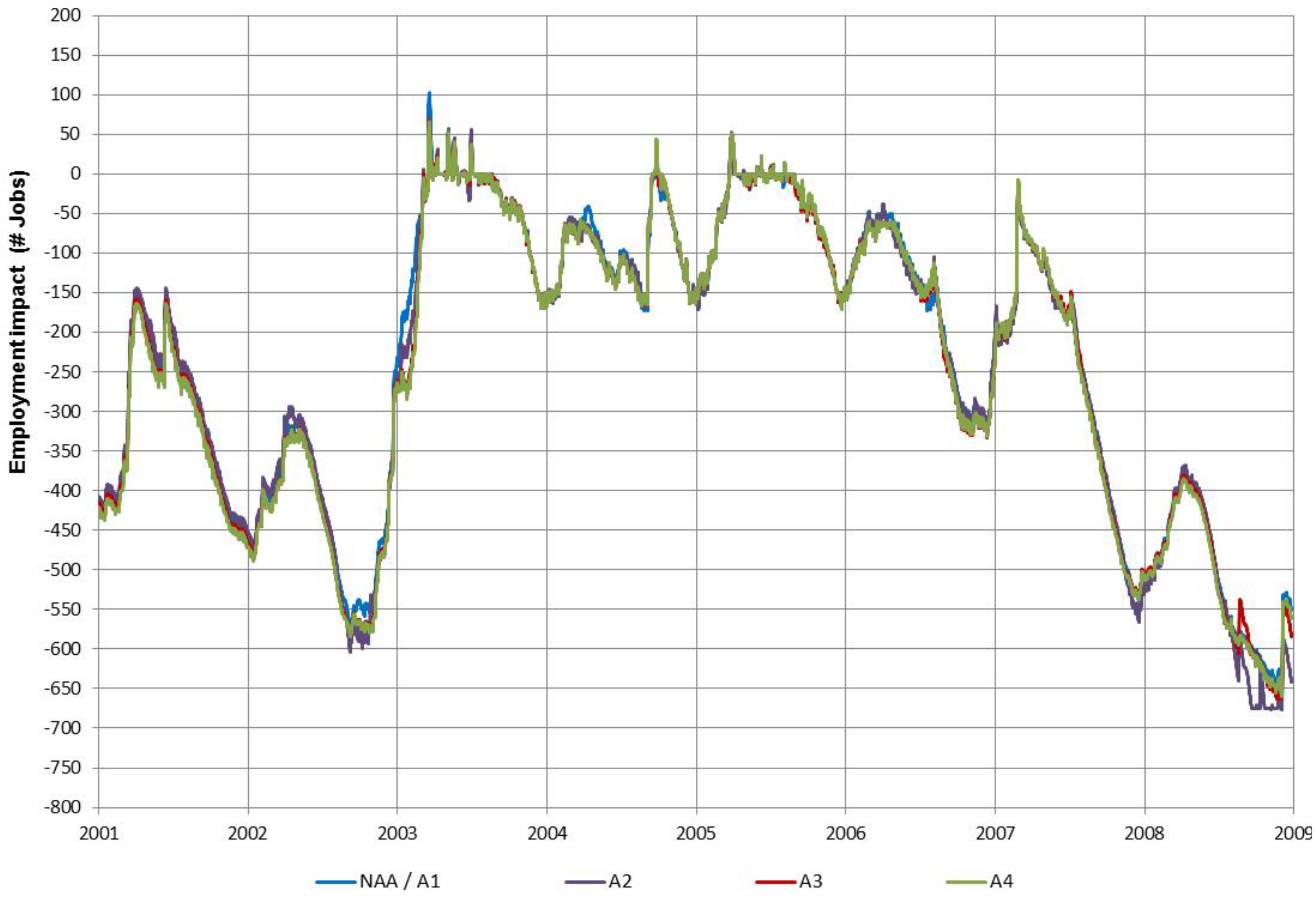


Figure 4.5-6 JST Lake Employment Impacts (With Future Water Withdrawals and Historic Hydrology)



Model Sensitivity Analysis

Using current water withdrawals instead of future water withdrawals results in similar impacts for each of the four alternatives. The economic and employment impacts are approximately 20 percent less than the impacts associated with the future water withdrawals with historical hydrology model assumptions, which is an expected outcome of the lower present volume of withdrawals. The 20 percent difference is substantial and state water managers may want to consider it as they make decisions in the future. See Figures Q-9 and Q-10 in Appendix Q for detailed results.

Using climate change hydrology instead of historic hydrologic conditions produces similar results from the economic model for all four alternatives. See Figures Q-11 and Q-12 in Appendix Q for detailed results.

Regional Economic Model Summary

Overall, regional economic impacts for each of the three reservoirs studied by STI are similar between the four alternatives. The region surrounding JST exhibited the largest economic impacts, by magnitude, followed by the Hartwell and Lake Keowee. However, all alternatives would produce comparable results in each of the three regional economic models. The Lake Keowee economic model was the only one that showed differences between alternatives near the end of the 2008 extreme drought. For Lake Keowee, A2 had the least impact (-$4,000 and four jobs lost) as no downstream releases are made if the release would cause Lake Keowee elevations to drop below 794.6 feet AMSL. NAA/A1 had the largest economic impact (-$12,000 and 12 jobs lost) as the reservoir level dropped to 782 feet AMSL. A3 and A4 results are similar to each other and fall between A2 and NAA/A1 results (-$6,000 and six jobs lost). The models identify the expected growth of water withdrawals in the future as producing the largest effects on the regional economy of the factors considered.

4.5.2 *Environmental Justice and Protection of Children*

The concept of environmental justice is based on the premise that no segment of the population should bear a disproportionate share of adverse human health or environmental effects. To address these concerns, Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority and Low Income Populations” was issued in 1994.

The concept of protecting children arises out of scientific evidence that demonstrates children may suffer disproportionately from environmental health and safety risks. To address these concerns, Executive Order 13045, “Protection of Children from Environmental Health Risks and Safety Risks” was issued in 1997.

The alternatives under consideration could alter reservoir elevations in the Upper Savannah River Basin and flows released from the JST Project to the lower Savannah River. Therefore, populations around those reservoirs and along the Savannah River downstream of JST could be affected. The HEC-ResSim modeling described in Section 3 reveals there would be only minor differences in reservoir elevations and downstream flow releases between the alternatives. These differences occur only during droughts.

NAA/A1 results in the lowest reservoir elevations for Duke Energy’s Jocassee and Keowee Lakes. This alternative also produces economic impacts related to forced outages at the ONS (see Sections 4.7.2 and 4.8) which result in energy replacement costs and/or transmission system upgrades of approximately $913 million and $232 million, respectively. A2 requires modifications of the ONS costing at least $800 million. These costs would likely be passed on to electric ratepayers in the Duke Energy service area and potentially other electric consumers. Because of the large number of Duke Energy customers, the impact to each individual customer would be relatively small. However, the increase would likely be felt more by those with low incomes.

The four alternatives exhibit similar minor results at the USACE reservoirs and downstream along the Savannah River. Since waterfront property is generally more expensive, residents that surround the Duke and USACE reservoirs would typically not be considered low-income. Therefore, impacts to pool levels from the alternatives would not be considered as affecting Low Income Populations. No impacts to minority and low-income populations are expected from the four alternatives. No environmental health and safety risks are expected from the four alternatives.

4.6 Coastal Zone Consistency

Under the NAA and all four alternatives, USACE would continue to implement its 2012 Drought Plan which defines how it would release water from JST Dam during droughts. That Plan was previously determined to be consistent with the Coastal Management Programs of both South Carolina and Georgia. Since that Plan would continue to be followed in each of the alternatives considered in this EA, no adverse impacts are expected to environmental resources in the coastal zone from implementation of any of the alternatives.

4.7 Electric Generation

4.7.1 *Hydroelectric Energy Generation*

To evaluate the differences in energy production between the alternatives, an energy impact assessment was conducted for the Bad Creek Project, Jocassee Pumped Storage Station, Keowee Hydro Station, Hartwell Project, RBR Project, and JST Project. While USACE's RBR Project and Duke Energy's Bad Creek Project were not constructed at the time of the 1968 Agreement, and are therefore not included in the present rules for determining flow releases from Lake Keowee, these two plants have been incorporated into the HEC-ResSim model.

Output from the HEC-ResSim model for each alternative included daily gross generation (in MWh) for all Duke Energy and USACE facilities, as well as average daily flow rates for each of the pumped-storage plants. The generation/pumping amounts were converted from MWh to dollars using monthly average energy values provided by SEPA (see Table 4.7-1).

Table 4.7-1 Average Energy Values for Power Purchase

Month	Average Energy Values ($/MWh)	
	On-Peak	Off-Peak
January	$77.60	$43.48
February	$68.62	$42.76
March	$79.01	$36.53
April	$69.71	$35.70
May	$66.79	$26.84
June	$91.81	$36.72
July	$90.39	$35.77
August	$87.37	$41.56
September	$64.71	$32.86
October	$60.82	$35.84
November	$57.15	$37.01
December	$73.19	$41.37

Source: Email from Douglas Spencer (SEPA) to Ed Bruce (Duke Energy) and Jason Ward (USACE) on 6/13/2011. Table compiled from SEPA's energy purchase records since Fiscal Year 2006.

The pumping flow rates were converted to dollars by first converting the average daily average flow (in cfs) to MWh using the pump performance curve for each pumped-storage plant. Once the MWh for each facility were determined, pumping energy was converted to dollars using average energy values provided in Table 4.7-1. Off-peak energy values were used for pump-back operations because those operations occur at night and on weekends when energy values are lower. Table 4.7-2 provides summary generation results for each of the alternatives as average annual net energy generation.

For the future water withdrawals with historic hydrology model results, there are minor differences in generation between alternatives for the Duke Energy system. The small differences in generation are the result of differences in available storage between alternatives. A2 has the smallest amount of available storage and the lowest generation, while A4 results in the most generation value. The difference between A4 and A2 is approximately $1.1 million each year. Net generation value for NAA/A1 and A3 is bracketed by A2 and A4 for the Duke Energy system.

There are only minimal differences between alternatives on a monthly basis for the USACE system (Figure 4.7-1). Figure 4.7-2 provides cumulative USACE generation along with cumulative Lake Keowee flow releases over the 73-year POR, and shows only minor differences between alternatives. Figure 4.7-3 provides a zoom-in of 2006-2011 to better illustrate the magnitude of differences between the alternatives. While there are differences between alternatives in the amount of flow released from Lake Keowee, these minor differences do not affect USACE system generation, as shown in the figure.

Table 4.7-2 Average Annual Net Energy Generation (1939–2011)

Owner	Average Annual Net Energy Generation							
	NAA/A1		A2		A3		A4	
	$ million	MWh	$ million	MWh	$ million	MWh	$ million	MWh
Future Water Withdrawals with Historic Hydrology								
Duke Energy[1,2]	92.1	(683,000)	91.1	(635,000)	91.9	(657,000)	92.2	(660,000)
USACE	120.4	1,478,000	120.4	1,478,000	120.4	1,478,000	120.4	1,477,000
System	212.5	795,000	211.5	843,000	212.3	821,000	212.6	817,000
Current Water Withdrawals with Historic Hydrology								
Duke Energy[1,2]	93.3	(667,000)	91.2	(619,000)	90.9	(620,000)	91.0	(620,000)
USACE	125.9	1,552,000	125.9	1,552,000	126.0	1,552,000	126.0	1,551,000
System	219.2	885,000	217.1	933,000	216.9	932,000	217.0	931,000
Future Water Withdrawals with Climate change Hydrology								
Duke Energy[1,2]	91.7	(684,000)	91.2	(636,000)	92.1	(661,000)	92.4	(663,000)
USACE	119.8	1,470,000	119.8	1,470,000	119.9	1,470,000	119.8	1,469,000
System	211.5	786,000	211.0	834000	212.0	809,000	212.2	806,000

[1] Average annual net generation for the Duke Energy system excludes generation impacts to ONS.
[2] MWh for the Duke Energy system are negative due to pumping operations at Jocassee Pumped Storage Station and the Bad Creek Project.

Figure 4.7-1 Monthly USACE Generation (Future Water Withdrawals with Historic Hydrology [1939–2011])

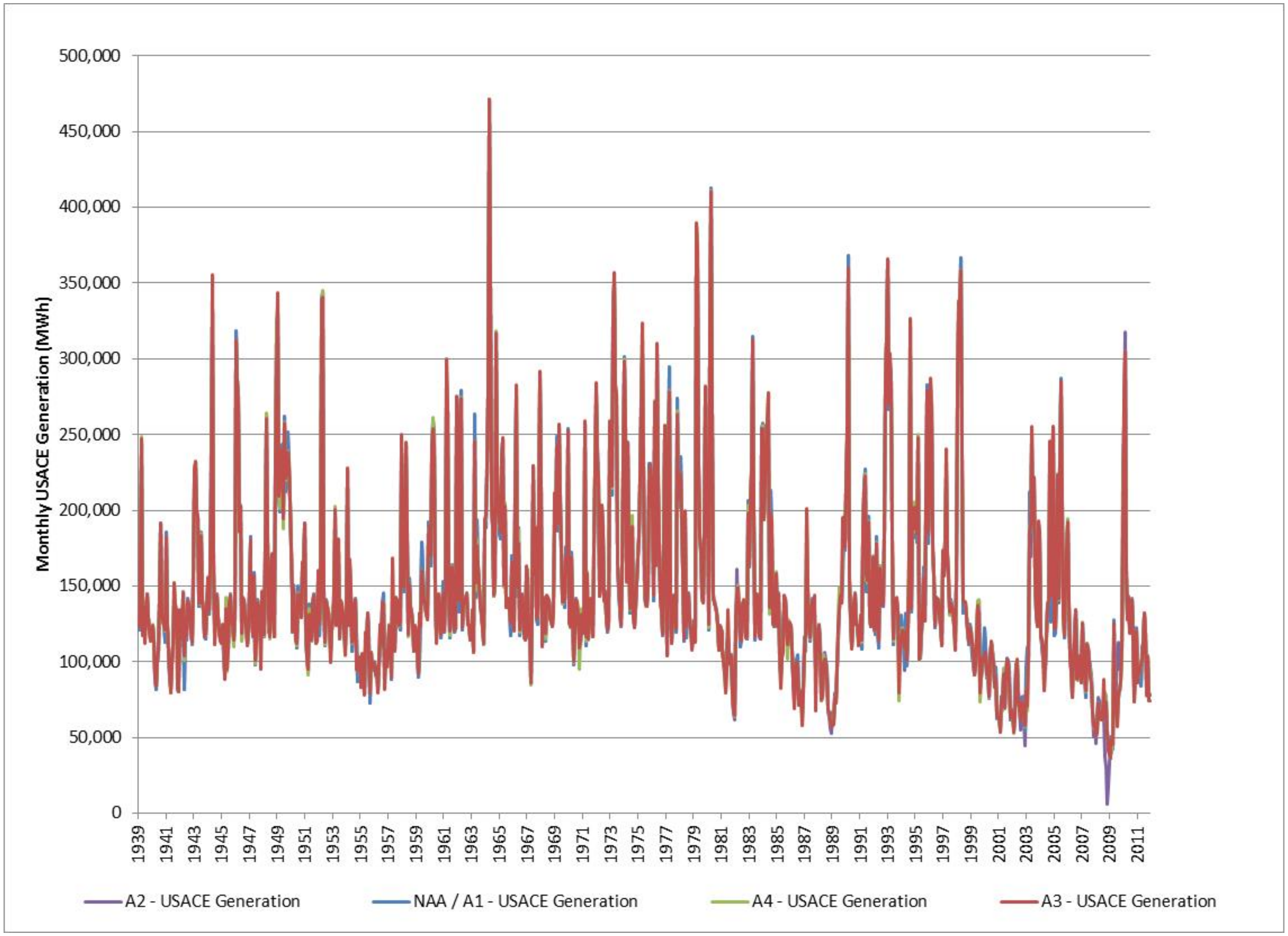


Figure 4.7-2 Total USACE Generation and Lake Keowee Release Volume (Future Water Withdrawals with Historic Hydrology [1939–2011])

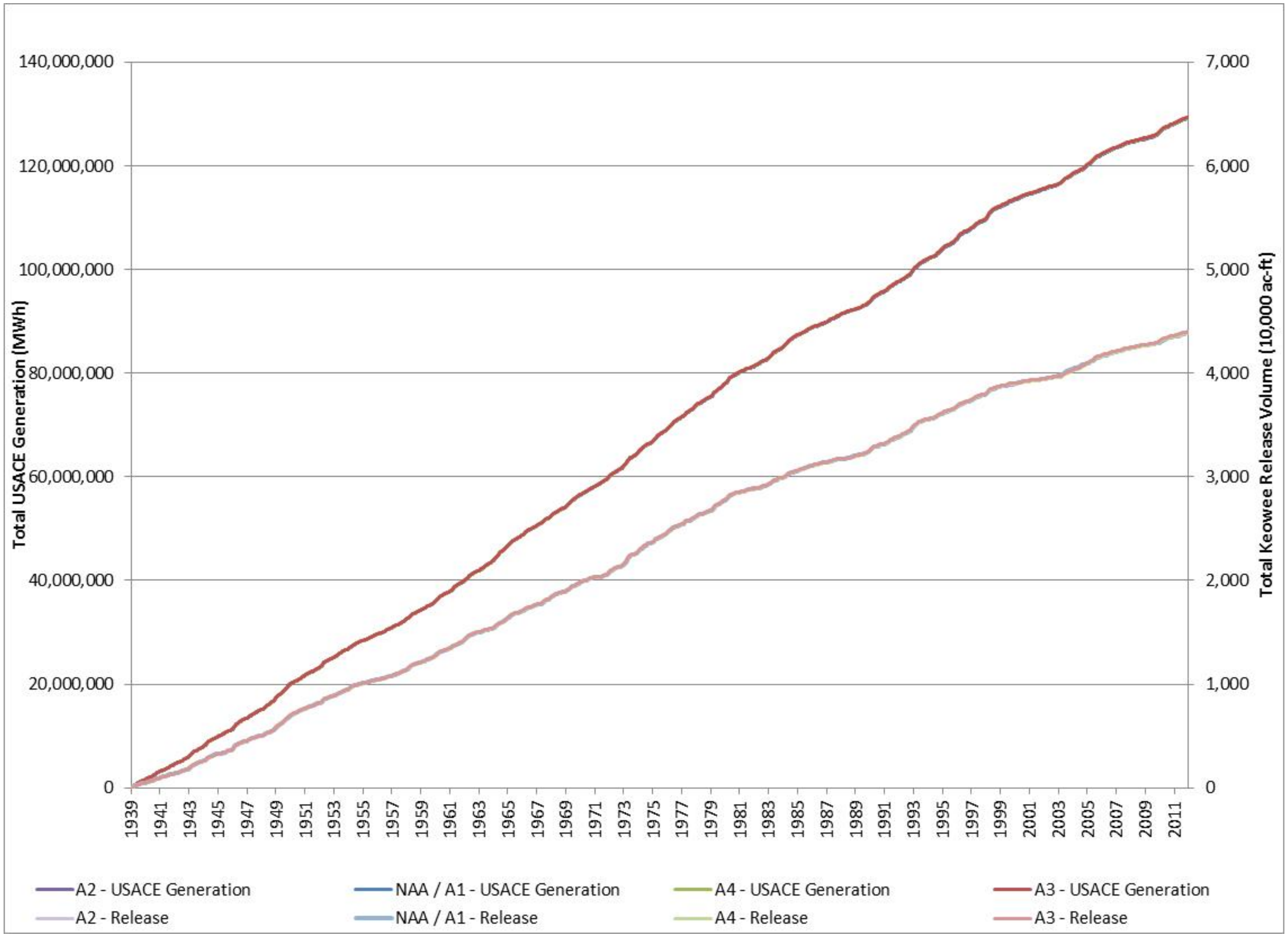
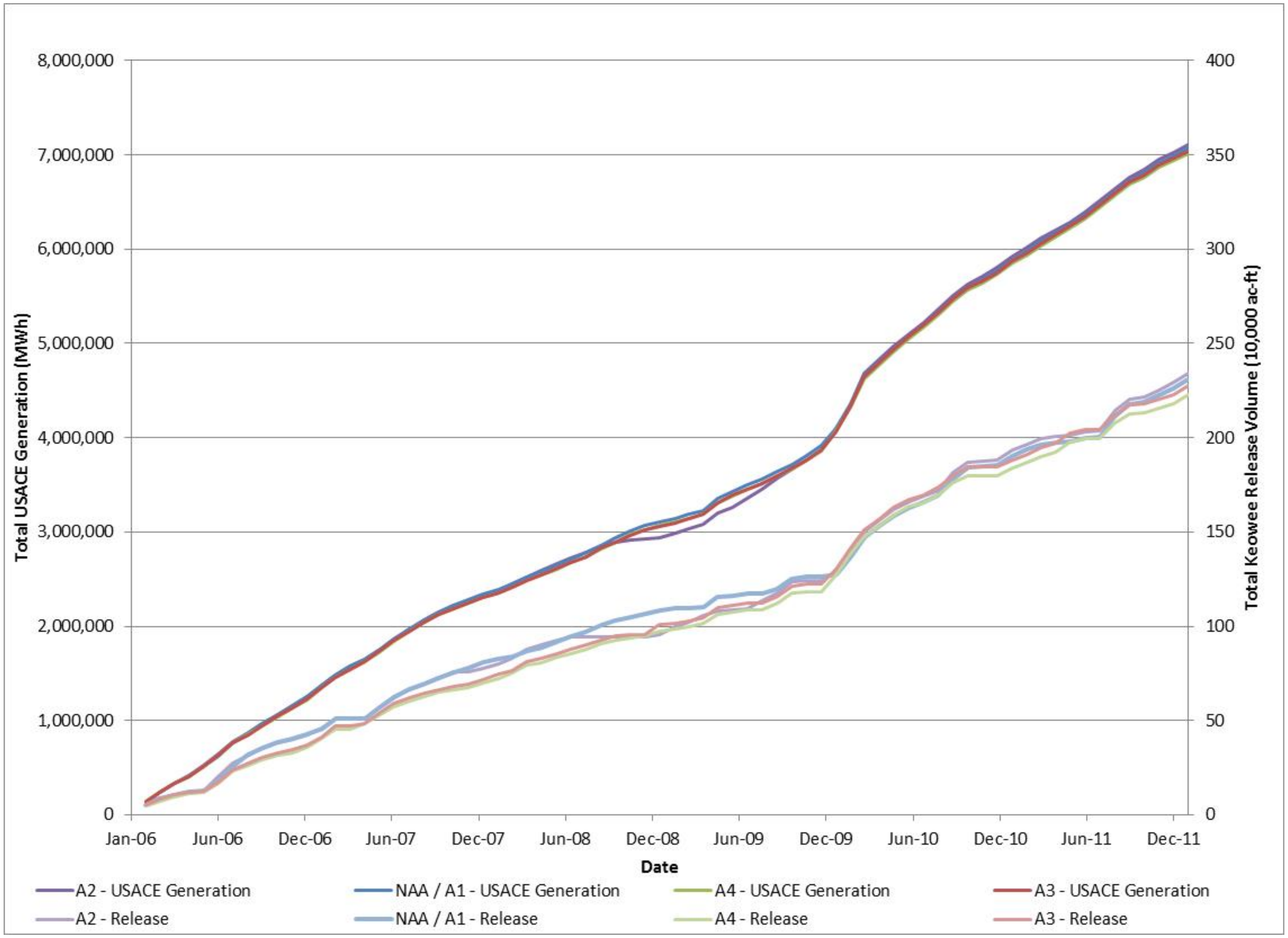


Figure 4.7-3 Total USACE Generation and Lake Keowee Release Volume (Future Water Withdrawals with Historic Hydrology [2006–2011])



Model Sensitivity Analysis

Using current water withdrawals instead of future water withdrawals results in a modest increase in generation for the Duke Energy system for two of the alternatives (NAA/A1 and A2), but shows a slight decrease in generation for A3 and A4. This is due to a decrease in generation at the Jocassee Pumped Storage Station resulting from the LIP logic, which keeps reservoir elevations higher and makes less water volume available for pump-back operations during drought periods (i.e., 2007) for A3. Added storage capacity from the Bad Creek Project along with a smaller usable storage capacity in Lake Keowee keeps Duke pool elevations higher in A4. The USACE system shows an annual average increase in generation of approximately $5.6 million for each alternative in this sensitivity analysis. Similar to the future water withdrawals with historic hydrology results, there are minor differences in USACE system generation (see Figures 4.7-4 through 4.7-6). The zoom-in of the 2006 – 2011 period in Figure 4.7-6 shows no difference in USACE system generation between alternatives and only minor differences between scenarios in Lake Keowee flow releases.

Figure 4.7-4 Monthly USACE Generation (Current Water Withdrawals with Historic Hydrology [1939–2011])

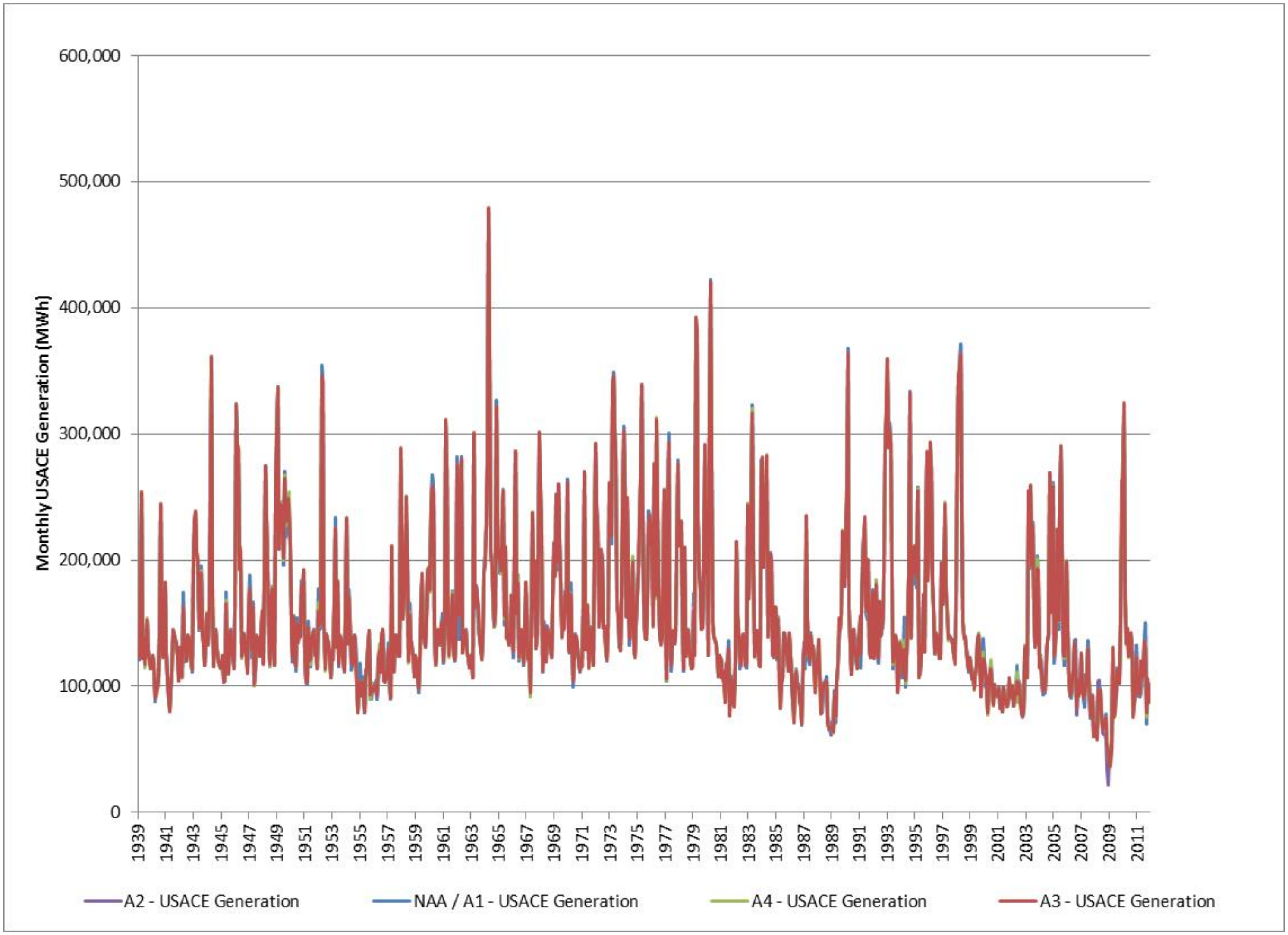


Figure 4.7-5 Total USACE Generation and Lake Keowee Release Volume (Current Water Withdrawals with Historic Hydrology [1939–2011])

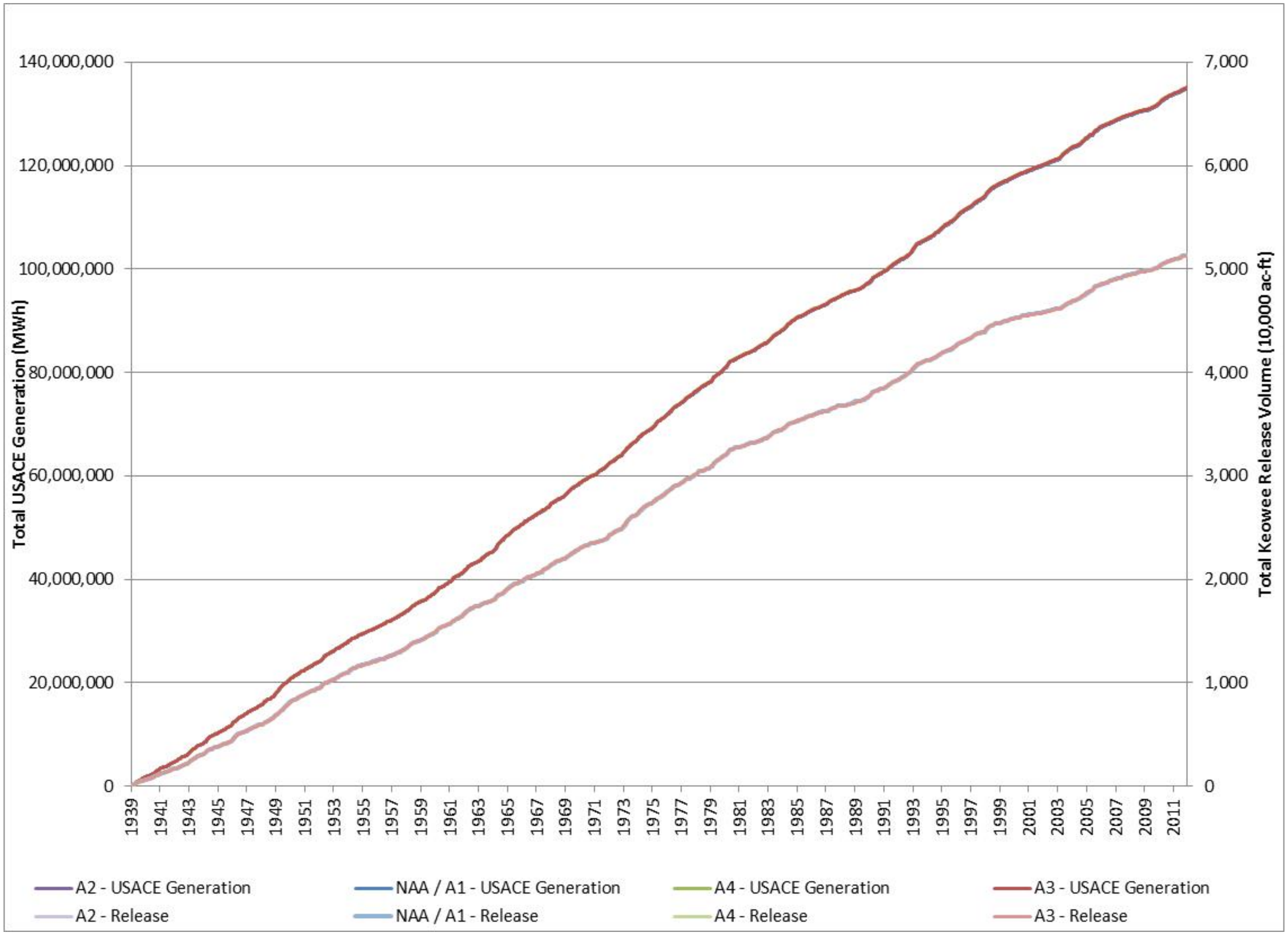
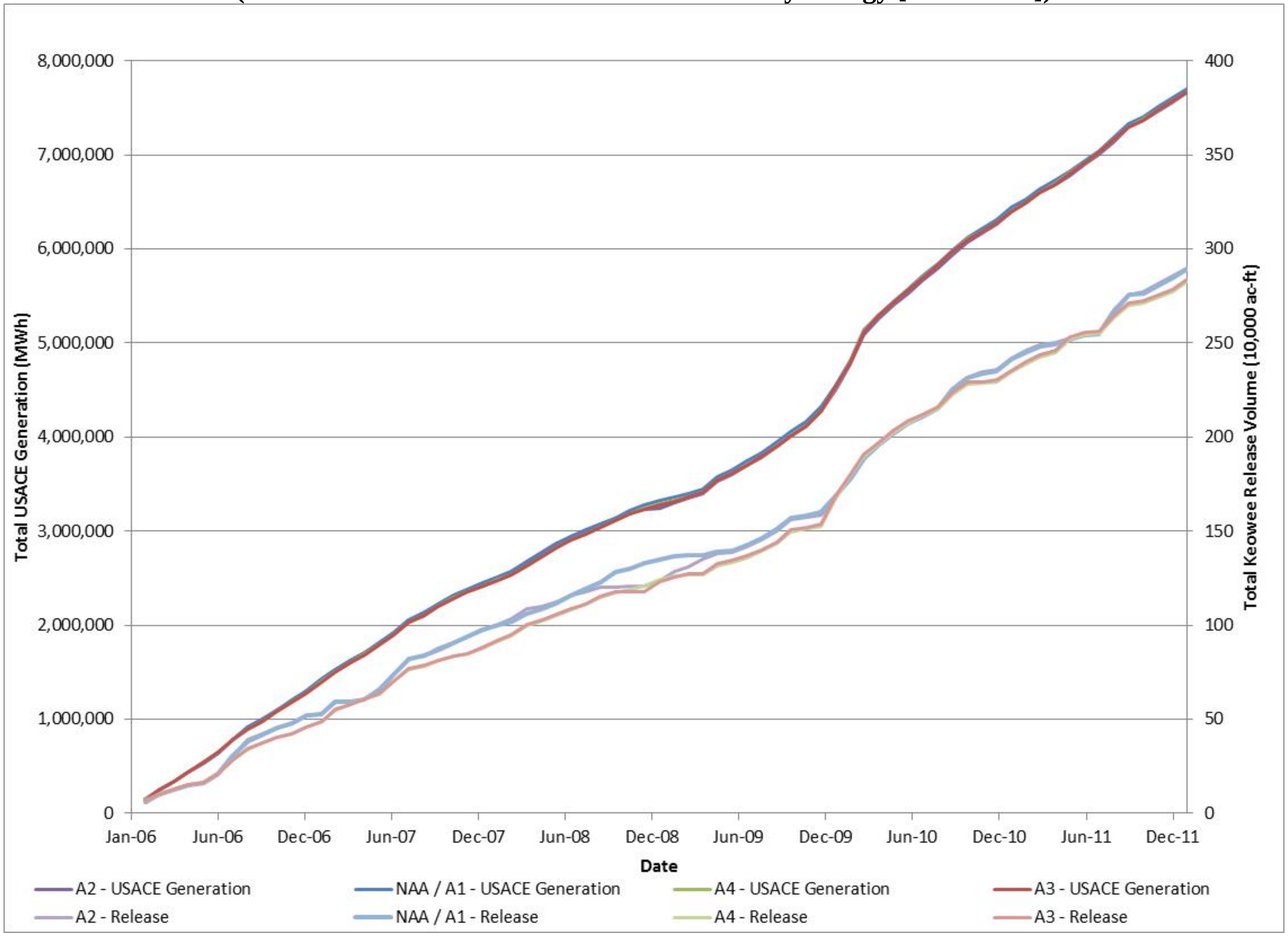


Figure 4.7-6 Total USACE Generation and Lake Keowee Release Volume (Current Water Withdrawals with Historic Hydrology [2006–2011])



Using climate change hydrology instead of historic hydrology results in less electric generation under NAA/A1 for both the Duke Energy and USACE systems. Electric generation would increase slightly in the Duke Energy system under A2, A3, and A4, while it would decrease slightly in the USACE's system. Under climate change hydrology, storage balance requirements for the Duke Energy system increase generation at the Jocassee Pumped Storage Station. Generation increases in A3 and A4 are also influenced by the inclusion of available storage at the Bad Creek Project. As a result, more water is available for pump-back and generation in A3 and A4. The USACE system experiences a decrease in annual average generation of approximately $600,000 for all model scenarios in the climate change scenarios.

Appendix T provides annual energy generation from the HEC-ResSim model results for all alternatives and sensitivity analyses.

4.7.2 *Oconee Nuclear Station Replacement Power*

Under NAA/A1, Duke Energy must shut down the ONS if Lake Keowee drops below 793 feet AMSL. During these periods, Duke would need to purchase replacement power to continue to serve its customers. 2,487 MW of generating capacity would need to be replaced for all months except April and November, which are typically outage months when one of the three ONS units is off-line for refueling. For these two months, only 1,658 MW of generation capacity would need to be replaced.

Over the 73-year POR, there was one extended period where Lake Keowee would have dropped below 793 feet AMSL (with the future water withdrawals and historical hydrology). This occurred during the extreme drought in 2008 and 2009. For NAA/A1, Lake Keowee dropped below 793 feet AMSL from June 20, 2008, through June 2, 2009, a total of 348 days. Using the monthly on-peak and off-peak energy values from Table 4.7-1 and an assumption that each week is comprised of 80 hours of on-peak energy and 88 hours of off-peak energy, the ONS replacement energy would cost approximately $913 million. This calculation includes the avoided cost of energy needed to power electrical systems during generation at the ONS.

Using current water withdrawals instead of future water withdrawals, replacement energy would be needed from July 28, 2008, through March 24, 2009, a total of 240 days. The resulting energy replacement cost is approximately $641 million, or $272 million less than with future water withdrawals.

Using climate change hydrology, replacement energy would be needed from June 11, 2008 through June 15, 2009, a total of 370 days. The resulting energy replacement cost is approximately $985 million, or $72 million more than with historic hydrology.

4.7.3 *Engineering Scenarios for Oconee Nuclear Station*

Enercon completed a conceptual level design study in April 2011 (Appendix G) that identified the feasibility and cost of modifications needed for the ONS to operate at Lake Keowee elevations lower than 793.7 feet AMSL (note this elevation does not include the additional operating margin of 0.9 ft used in the HEC-ResSim model runs). Modifications to the ONS to allow it to operate down to a Lake Keowee elevation of 777.1 ft AMSL are included in A1.

Options considered in the study included:

- Upgrades to the CCW system pumps, discharge valves, and associated motors and controls to allow plant operation at a Lake Keowee level of 787 ft AMSL (Part 1 Option 1a)
- Reducing flow of the LPSW and HPSW systems (by reducing or eliminating non-essential loads during loss of offsite power events) to reduce these systems' required net positive suction head (NPSH) (Part 1 Option 1b)
- Upgrades to the CCW pumps, discharge valves, and their associated motors and controls to allow plant operation at a Lake Keowee level of 787 ft AMSL (Part 1 Option 1c)
- Upgrades to the CCW pumps, discharge valves, and their associated motors and controls to allow plant operation at a Lake Keowee level of 777.1 ft AMSL (Part 2 Option 1)
- Upgrades to the CCW pumps, discharge valves, and their associated motors and controls to allow plant operation at a Lake Keowee level of 777.1 ft AMSL (Part 2 Option 2)

Enercon thoroughly investigated each option via plant walkdowns, site personnel interviews, document research, and hydraulic analyses. They prepared conceptual designs for each option and evaluated them for feasibility, plant impact, and licensing basis impact. They developed cost estimates for each option and included design costs, procurement costs, implementation costs, and annual operations and maintenance (O&M) costs.

Enercon's study concluded that all of the options considered are potentially feasible and can meet their stated target reduction in Lake Keowee elevation. The study did not attempt to make a recommendation, but rather it provided a detailed evaluation of the feasibility of plant modifications that would reduce required Lake Keowee reservoir elevations and developed cost estimates for each option. Table 4.7-3 summarizes the estimated capital cost and annual O&M costs for each option they considered. (See Figure 4.7-7)

Since Enercon completed the feasibility/conceptual design study in April 2011, Duke Energy has further reviewed potential design modifications allowing the ONS operations at Lake Keowee elevations below 794.6 feet AMSL. These design modifications would use some elements of the modifications outlined in some of the options in Table 4.7-3, but other plant specific design and system considerations will require costs in addition to the costs specified in Table 4.7-3. Design modifications are currently scheduled to be implemented by November 30, 2019.

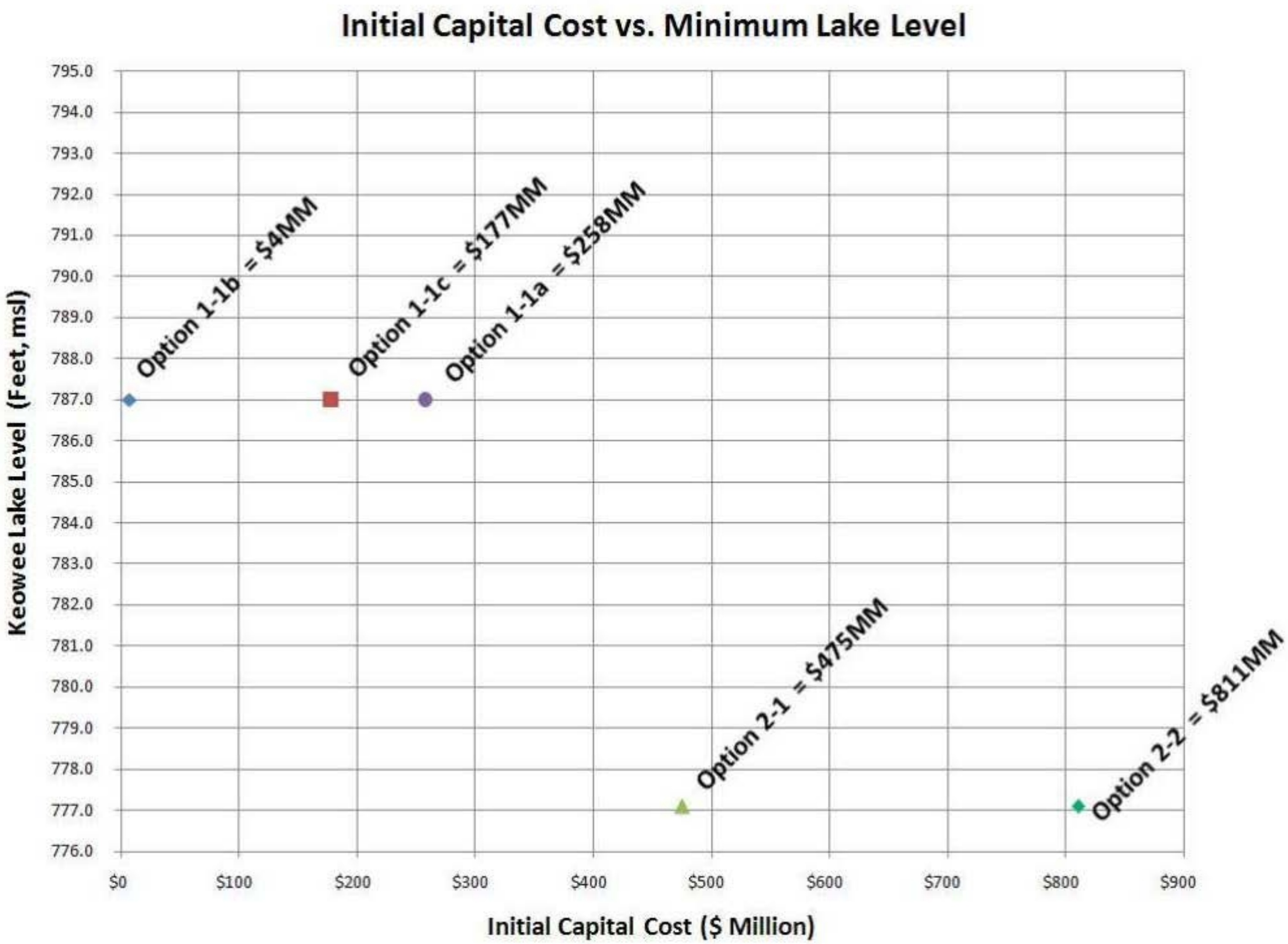
Table 4.7-3 Project Cost Estimates and Minimum Reservoir Elevations

Option	Capital Cost	Annual O&M Cost	Reduced Lake Level (ft msl)
1-1a- Upgrade twelve CCW pumps / motors and CCW discharge valves / motors to QA1, and power from SR DGs	$257,553,509	$434,248	787
1-1b- Reduce required NPSH for LPSW and HPSW pumps. This option consists of LPSW flow reduction option L1 (component cooler isolation modification), option L5 (analytically accounting for isolation of the non-essential LPSW header), reduction of HPSW flow to 5400 gpm, and addition of booster pump to increase NPSH available to CCSW pumps	$3,660,335	$36,400	787
1-1c- Add sufficient safety related conductors and transformer capacity to allow use of Keowee Hydro power for CCW pumps / motors and CCW discharge valves / motors upgraded to QA1.	$177,016,658	$106,600	787

Option	Capital Cost	Annual O&M Cost	Reduced Lake Level (ft msl)
2-1- Replace underground SR power supply from Keowee Hydro with SR DGs sufficient in size to power emergency loads (including CCW) during a site wide LOOP and a LOCA on one unit or power the PSW loads.	$475,094,105	$710,924	777.1
2-2- Replace underground SR power supply and overhead non-SR power supply from Keowee Hydro with DGs sufficient to power emergency loads (including CCW) during site wide LOOP and LOCA on one unit or power the PSW load; additionally power non-SR BOP loads currently powered from Keowee Hydro overhead line.	$810,656,722	$1,418,473	777.1

Note: Elevations do not include any operating margins
Source: Enercon 2011.

Figure 4.7-7 Initial Capital Cost Versus Minimum Reservoir Elevation



Source: Enercon 2011.

4.8 Electric Transmission

At USACE's request, Duke Energy assessed potential impacts to electric transmission system from shutdown of all three ONS generating units under the NAA/A1 under extreme drought conditions. It focused on grid stability and reliability issues. The study identified overloaded transmission lines and/or transformers that would need to be rebuilt or replaced and construction activities that should be accelerated under NAA/A1. The study provides a cost basis for comparison of the action alternatives to the No Action Alternatives.

Duke investigated generator instability issues. Instabilities can arise from the unplanned tripping of a transmission line. Depending on a number of factors, this can cause a generator to be tripped. Under worst case conditions, this could cause a total loss of the transmission grid. A stability study uses a computer program whose initial conditions are set to generate and load data for the particular "peak" or "valley" period being studied. The program systematically trips each transmission line (one line for each computer run) and analyzes the effect on each generator. This approach is standard industry practice and was used for the load scenarios being investigated. The analysis concluded that ONS shutdowns would not result in transmission system stability concerns throughout the southern region. Therefore, grid stability is not a major concern.

Transmission line and transformer overloads were investigated. The actual generation and loading data for 2010 (including seasonal "peaks" and "valleys" but excluding the ONS units), were used as the baseline. These baseline conditions were then increased by projected growth factors for years 2013, 2017, and 2021. These years were selected based on current transmission planning models and generation scenarios. Model results were evaluated to identify overloaded transmission lines and transformers. Only the overloads created by the absence of the ONS units were included in the analysis. Based on the results of a previous study, the overloads driven by this type of event would most likely occur during the summer peak. This study focused only on summer peak load levels, but recommended that 10 percent be added to the total cost to account for the winter peak, fall peak, and fall valley periods that were not considered in this analysis.

For the summer peak scenario, an estimated cost was determined to rebuild or replace each overloaded line and/or transformer. This analysis included generators from Duke Energy, Tennessee Valley Authority (TVA), South Carolina Electric and Gas (SCEG), and Southern Company (SOCO). The estimated cost to address transmission line and transformer overloads in the NAA is $232 million. Major transmission system components (i.e., conductors and transformers) would need to be upgraded to address reliability concerns. Due to long lead times associated with these upgrades, planning activities would need to begin as soon as possible and upgrade costs would extend for many years.

The complete study is included in Appendix U. Summary estimated cost results are provided in Table 4.8-1.

Table 4.8-1 Transmission Impacts Related to Potential ONS Shutdowns

Season Load Level	Line / Transformer Upgrades	Capital Costs (2012 dollars)		
		Non-Duke	Duke	Total
Summer Peak (B)	31 / 5	$60,800,000	$149,900,000	$210,700,000
Overall with 10% Added	34 / 6	$66,900,000	$164,900,000	$231,800,000

4.9 Solid and Hazardous Waste Facilities

The average flow releases below JST remain at or above 3,100 cfs for all four alternatives. Therefore, it is unlikely any of the alternatives will impact solid and hazardous waste facilities located in South Carolina and Georgia and all modeled scenarios would have comparable effects.

4.10 Cultural Resources

As described in Section 2.15, during the droughts of 2006, 20011 and 2012, USACE evaluated potential effects on cultural and historic resources listed in or eligible for inclusion in the NRHP resulting from varying pool levels. The evaluations included consultation with Native American tribes, the ACHP, the South Carolina and Georgia SHPOs, the Augusta Canal Authority, and other appropriate parties. The Augusta Canal Authority indicated flows in the Savannah River less than 3,000 cfs would negatively affect the use of the Augusta Canal National Heritage Area for recreational purposes, as well as operation of the Petersburg Tour Boats. No other parties identified concerns regarding the potential effects of flow rates in the USACE Drought Plan on historic properties downstream of its reservoirs. For each of the four alternatives, average flows released downstream from the JST Project would be at or above 3,100 cfs, the minimum flow required to avoid adverse effects to the Augusta Canal National Heritage Area.

At this time, USACE has not fully documented the effects that fluctuating water levels have had on cultural resources within its USACE reservoirs. As such, it is not certain how the management of reservoir elevations is impacting these resources. The proposed alternatives would reduce pool elevations in the USACE reservoirs during severe droughts, but would not empty the USACE Conservation Pools. The original design of the USACE reservoirs was to have them decline to the bottom of their Conservation Pools during the worst drought. Since the minimum pool levels would still be above the bottom of the Conservation Pool with the proposed alternatives, they would not expose any submerged lands that were not intended to be exposed during severe droughts. However, comprehensive cultural resource surveys were not performed before the Hartwell and Thurmond reservoirs were flooded. As a result, the locations of all significant historic or cultural resources on the bottom of the reservoirs, along their shorelines, and on the adjacent Federal uplands are not completely known. With substantial water depths in many locations, such surveys are quite difficult to perform.

In 2011 as part of the Level 4 Drought Operations EA, USACE developed and agreed to implement a Programmatic Agreement, and survey inundated areas that are affected by changes in Level 4 drought operations to identify and evaluate properties eligible for the National Register of Historic Places. It would also identify and evaluate alternatives to avoid and/or mitigate adverse effects on those properties. The Programmatic Agreement was updated slightly in the 2012 Drought Plan and that document contains the same commitments to protect cultural resources. USACE would continue to follow the 2012 Drought Plan in each of the alternatives considered in this EA and incorporates the 2012 Programmatic Agreement into this document by reference. Implementation of the Programmatic Agreement will increase understanding of the effects of fluctuating water levels on archaeological sites within the project area.

As discussed in Section 2.15, FERC executed a Programmatic Agreement with the South Carolina SHPO in 2007 for managing historic properties potentially affected by implementation of the Shoreline Management Plan for the Keowee-Toxaway Project. Duke consulted with Indian tribes, the North and South Carolina SHPOs, and other appropriate parties to identify, assess, and resolve adverse effects on historic properties potentially affected by relicensing the Keowee-Toxaway Project. Since no historic properties have been located at Lake Jocassee, no impacts to historic properties are expected at that site. Three archaeological sites that may be eligible for the National Register have been located at Lake Keowee. None of the proposed alternatives are expected to affect those properties.

All alternatives would have minor and similar effects on cultural resources.

4.11 Navigation

Although navigation is one of the Congressionally-authorized purposes of the USACE reservoirs, USACE does not set aside any reservoir storage or identify any pool elevation to support downstream navigation. Similarly, no minimum flow requirements have been established to support navigation in the lower Savannah River. Since USACE would continue to implement the minimum releases from JST identified in its 2012 Drought Plan in each alternative, none of the alternatives would affect downstream navigation.

5.0 CONCLUSIONS

As summarized below, there are only minor differences in environmental, socioeconomic, and hydroelectric generation effects between the alternatives. Although the changes from the alternatives would only result in small changes in USACE pool elevations, those changes under A3 and A4 would result in substantial losses in recreational use over the 50-year period of analysis. Mitigation would be included in those two alternatives to fully compensate for those impacts. All action alternatives eliminate the substantial energy replacement and transmission system upgrade costs resulting from temporary shutdowns of the ONS during extreme droughts (approximately $913 million and $232 million, respectively) associated with NAA. A1 includes substantial costs associated with modifying the ONS to meet the requirements of the 1968 Agreement ($800 million in capital costs, without additional O&M costs). Such costs would likely be passed on to electric ratepayers in the region, make the NAA and A1 undesirable alternatives from an economic perspective. A2, A3, and A4 are very similar with respect to reservoir elevation, generation, and socioeconomic effects.

Duke Energy System Water Volume Available for Downstream Flow Releases

Reservoir storage calculations are completed on a weekly basis for the USACE and Duke Energy systems and required flow releases from Keowee Hydroelectric Station are determined. Figure 3.2-1 showed the volume of water available for use from the Keowee-Toxaway and Bad Creek Projects as the percent of remaining usable storage in the USACE system declines (uses include municipal water withdrawals from Lake Keowee, ONS uses, and flow releases to the USACE reservoirs, in addition to natural surface evaporation).

Among the five alternatives, NAA and A1 have the largest volume of water available for use from Lake Keowee as the pool would be allowed to decline to 778 feet AMSL. However, making this volume of water available requires a substantial cost to Duke Energy either through a shutdown of the ONS in NAA or through expensive modifications to the ONS in A1. Neither of those two alternatives is consistent with Duke's 2014 stakeholder agreement for relicensing of the Keowee-Toxaway Project.

A2 assumes no flow release is made from Lake Keowee if that release would result in the reservoir level dropping below 794.6 feet AMSL. With this alternative, Duke Energy would not release water from its system once the USACE system storage drops below approximately 43 percent if inflows are not sufficient to meet all on-reservoir water use demands for the Keowee-Toxaway Project.

While less water is available for use in A3 and A4 when the USACE system storage is between 100 and 25 percent (compared to NAA, A1, and A2), more water would be available for use (compared to A2) when the USACE system storage level drops below 25 percent during severe droughts.

Hydrologic Modeling

USACE's HEC-ResSim hydrologic model was used to simulate reservoir elevations, usable storage, and flow releases from the Duke Energy and USACE reservoirs in the Upper Savannah River Basin, including flow releases from JST Reservoir. Two alternatives (NAA and A1) are the same from a reservoir modeling perspective and did not require separate model simulations. The analyses use future water withdrawals and historic hydrology. Additional analyses were performed to identify the sensitivity of the results to an alternate assumption in (A) water withdrawals (current rather than future), and (B) climate (climate change rather than historic hydrology).

Differences between alternatives are only evident during droughts. Those differences are usually small in magnitude (particularly for the USACE reservoirs and the lower Savannah River Basin), infrequent (only occurring during droughts), and are not expected to have long-term effects on environmental conditions.

For Lakes Jocassee and Keowee, A3 and A4 are almost identical and result in reservoir elevations higher than NAA/A1 and A2. The only time A2 maintains higher Lake Keowee reservoir elevations is during extreme droughts. The available storage in Lake Jocassee is used during droughts to help maintain Lake Keowee pools as long as possible to support operation of the ONS.

For the USACE reservoirs, differences in pool elevations are observed during extreme droughts. The differences in pool elevation occur infrequently (only during extreme droughts) and are relatively short in duration (i.e., 2 to 3 months).

The USACE and Duke Energy remaining usable storage is greater than 60 percent during the majority of the POR. All alternatives would result in similar amounts of available storage. With A3 and A4, the usable storage would drop below 12 percent in both the USACE and Duke Energy reservoirs under extreme drought near the end of 2008. When that occurs, Duke Energy would not be required to provide a weekly scheduled storage balance release from the Keowee Hydroelectric Station. However approximately 650 ac-ft per week is released continuously via seepage and leakage through the Keowee Development, so some inflow would continue to occur to the USACE reservoirs.

USACE would continue to release the minimum flows from JST during droughts that were identified in USACE's July 2012 Drought Plan. This means that the volume of water USACE discharges through JST would be the same in the NAA and the action alternatives. However, those discharges would be reduced for longer periods of time with the action alternatives because the USACE pools would be lower and USACE would operate the system under the Drought Plan for more days.

Environmental Effects

The HEC-ResSim modeled differences in reservoir elevations and downstream flow releases might affect water supply; water quality; recreation opportunities; and aquatic, wetland, and wildlife resources for the five alternatives. During non-drought and wet hydrologic periods, there were no differences between model scenarios in reservoir elevations or flows released from the JST Project. As a result, during these periods, the effects of all alternatives on water supply, water quality, recreation opportunities, or natural resources in the Savannah River Basin are comparable.

During drought conditions, there were some differences between alternatives that could affect environmental conditions and natural resources. Most, if not all, of the differences are relatively minor, infrequent (i.e., only occur during the most severe parts of the droughts), and short-lived. As described above, these differences were the greatest at Lakes Jocassee and Keowee. A3 and A4 generally result in Lake Jocassee and Lake Keowee reservoir elevations higher than they are under NAA/A1 and A2, which could generally benefit environmental conditions and natural resources.

- Effects Associated with Lake Jocassee Reservoir Elevations: The effects of large reservoir drawdowns at Lake Jocassee have been the subject of a water quality and fish habitat monitoring program (undertaken by Duke Energy) which identified no long-term detrimental impacts to fish or biota living in or using the reservoir. Recreation opportunities on Lake Jocassee likely diminish during large reservoir drawdowns, but access to the reservoir is still available. A3 and A4 maintain higher reservoir elevations compared to NAA/A1 and A2 and would result in the least impacts to environmental conditions and natural resources. Recreational users of the reservoir would benefit from the higher pool levels in A3 and A4.

- Effects Associated with Lake Keowee Reservoir Elevations: For Lake Keowee, only NAA/A1 results in reservoir drawdowns greater than 10 feet, which occur twice during the 73-year POR. All public boat ramps become unusable at drawdowns greater than 13 feet; that is a lower elevation than observed in any alternative, except during the most severe drought in the 73 year period of record. Municipal water supply intakes on Lake Keowee are below the largest modeled drawdown (i.e., 782 feet AMSL) and would not be affected. Most alternatives maintain reservoir elevations within the upper five feet of the reservoir, with only small differences occurring between alternatives. Therefore, differences between the alternatives in effects to water quality and aquatic, wetland, and wildlife resources are minimal.

- Effects Associated with USACE Reservoir Elevations: For the USACE reservoirs, small differences in reservoir elevations between alternatives occur during droughts. In general, those impacts are only 2 - 3 months in duration. Water intakes (and supply) are not expected to be impacted by any of the alternatives. Reservoir drawdowns during droughts result in periods where public boat ramps are unusable. A2 would reduce the number of days boat ramps would be unavailable, while the number of days would increase in A3 and A4. The expected effects on recreation would be as follows: A2 - $898,000 benefit per year; A3 - $2,938,000 adverse impact per year; and A4 - $3,626,000 adverse impact per year. The adverse impacts would be fully compensated by mitigation that would increase recreational access to the USACE reservoirs. The effect on natural resources from changes in the drawdown during droughts would be similar for all four alternatives.

- Effects Associated with JST Flow Releases: Differences in environmental effects between the alternatives are negligible in the lower Savannah River. As droughts become more severe, HEC-ResSim model results indicate downstream average flow releases become more similar between alternatives. Since USACE would continue to follow the conditions of its 2012 Drought Plan, the average daily volume of water released from JST would be the same under all alternatives. Since the USACE pools would drop lower during droughts in A3 and A4, the reduced flow levels identified in the Drought Plan would occur for a longer duration with A3 and A4. The number of additional days varies by drought level (see Section 3.7.1). To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor, the action alternatives include the following provision: USACE and Duke Energy will discharge 200 cubic feet per second of water above that specified in the Drought Plan from their dams for 11 days when the USACE reservoirs are in drought status during the summer months.

Hydropower Generation

HEC-ResSim model calculates hydropower generation expected at each of the Duke Energy and USACE Projects. Differences in average annual net energy generation in the Duke system between alternatives are relatively minor (Table 4.7-2). A4 results in the highest net annual generation for the Duke Energy system at $92.2 million and NAA/A1, A2, and A3 are slightly lower ranging from $91.1 - $92.1 million. As a result, the maximum difference between scenarios for the Duke Energy system is $1.1 million ($92.2 - $91.1 million) on an annual basis. There is no difference in net hydroelectric generation between alternatives for the USACE system (Table 4.7-2).

Oconee Nuclear Station Economic Impacts

Under the NAA, Lake Keowee reservoir levels would fall below 793 feet AMSL for a 348-day period in 2007–2008. The resulting forced outage at the ONS would have resulted in energy replacement costs estimated at $913 million. In addition, costs to upgrade the existing electric transmission system to lessen the severity of grid reliability issues while the ONS is off-line are estimated at $232 million. Implementation of those transmission system upgrades would have to begin immediately to avoid grid reliability issues in the future (under this alternative).

Duke Energy evaluated options that would allow it to continue to operate the ONS at lower pool elevations. Those modifications include upgrades to the CCW system (i.e., pumps, discharge valves, and associated motors and controls) and reductions in the flow of the low-pressure and high-pressure service water systems by reducing or eliminating non-essential loads during loss of offsite power events. Duke Energy identified the most cost effective modifications that would allow it to operate the ONS at various elevations of Lake Keowee below 794.6 ft AMSL. No modifications to the ONS are included in the NAA.

Under A1, Duke Energy would modify the ONS so that its operations are not tied to Lake Keowee elevations. From a water management perspective, A1 decouples the ONS from the Keowee Hydroelectric Station through installation of diesel generators that would serve as the primary backup power supply. Duke estimates the cost of installing those diesel generators to be at least $800 million, not including O&M costs.

No modifications to the ONS are included in A2. Duke Energy's cost to modify the ONS in A3 and A4 is approximately $2 million.

Socioeconomic Impacts

Regional Economic Models

The Strom Thurmond Institute developed regional economic models for the counties surrounding Duke Energy's Lake Keowee and the USACE Hartwell and JST Reservoirs. These models rely on three parameters as indicators of economic change: recreational use at each reservoir, real estate transactions around each reservoir, and the sale of reservoir-related goods and services (e.g., sporting goods, bars, boating stores, etc.). The models evaluated regional economic conditions (both positive and negative) associated with every foot of water elevation change in these three reservoirs. The economic model results span 2001–2008, which includes the drought of record in 2008. The impacts of the proposed alternatives were found to be minor at each reservoir.

For Lake Keowee, during the majority of the period modeled, differences between alternatives are within $2,000 of each other and three jobs over the eight-year study period (see Figures 4.5-3 and 4.5-4). The largest differences occur near the end of 2008 and are the result of the extreme drought. During this period, NAA/A1 results in the largest economic impact to the region (a loss of $12,000 and 12 jobs) as Lake Keowee's reservoir elevation drops to 782 feet AMSL. A2 results in the least impact (a loss of $4,000 and four jobs) because flow releases would not be made if they would result in Lake Keowee dropping below 794.6 feet AMSL. A3 and A4 are similar to each other and fall between A2 and NAA/A1 results (a loss of $6,000 and six jobs).

For Hartwell and JST Lakes, during the entire period modeled, economic and employment impacts are similar for all alternatives. See Figures 4.5-1 and 4.5-2 for Hartwell Lake results and Figures 4.5-5 and 4.5-6 for JST Lake results.

The sensitivity analyses indicate that economic effects from drought-induced reservoir drawdowns increase substantially over the NAA with expected future increases in water withdrawals and with the Climate Change scenario.

Environmental Justice and Protection of Children

The analysis considered potential impacts to populations of minorities, low income households, and children (who may suffer disproportionately from environmental health and safety risks) and would most likely be affected by differences in reservoir elevations and flows released from the JST Project to the lower Savannah River. Based on the HEC-ResSim model results, those differences would be small in both the reservoir and downstream. These differences occur during extreme drought and are widespread. As a result, negligible impacts are expected to minority and low-income populations, or environmental health and safety.

Overall Summary of Results

Tables 5.0-1 and 5.0-2 provide a summary of HEC-ResSim, economic, environmental and socioeconomic results.

**Table 5.0-1 HEC-ResSim Model and Economic Results Summary
(Future Water Withdrawals with Historic Hydrology)**

Resource		Alternatives				
		NAA	**A1**	**A2**	**A3**	**A4**
Duke Energy Avg Reservoir Elev (ft AMSL)	Lake Jocassee	1104.6	1104.6	1105.0	1106.4	1106.3
	Lake Keowee	797.7	797.7	797.9	798.4	798.4
USACE Avg Reservoir Elev (ft AMSL)	Hartwell Lake	656.9	656.9	657.0	656.8	656.7
	RBR Lake	475.5	475.5	475.5	475.2	475.2
	JST Lake	327.1	327.1	327.1	327.1	327.0
Minimum Remaining Usable Storage (%)	Duke Energy	17	17	42	11	10
	USACE	16	16	20	13	13
JST Project Avg Flow Releases (cfs)		6,074	6,074	6,076	6,082	6,078
Approximate Largest Socioeconomic Loss ($ / Jobs)	Lake Keowee	12,000 / 12	12,000 / 12	4,000 / 4	6,000 / 6	6,000 / 6
	Hartwell Lake	30,000 / 25	30,000 / 25	28,000 / 24	30,000 / 26	31,000 / 27
	JST Lake	500,000 / 650	500,000 / 650	510,000 / 660	510,000 / 660	510,000 / 660
Average Annual Net Hydroelectric Generation ($ Million)	Duke Energy	92.1	92.1	91.1	91.9	92.2
	USACE	120.4	120.4	120.4	120.4	120.4
ONS Economic Impacts ($ Million)	Replacement Energy	913	n/a	n/a	n/a	n/a
	Transmission System Upgrades	232	n/a	n/a	n/a	n/a
	Station Modifications	n/a	>800	n/a	2	2

Table 5.0-2 Environmental and Socioeconomic Results Summary

Resource		Modeling Parameter	Alternative Comparison with NAA / A1		
			A2	A3	A4
Water Supply	Water Intake Operation	Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); Smaller drawdowns for the Duke Energy System; Alternative includes measures to reduce consumptive water uses at Keowee during droughts	Little to no difference (<1 ft); Smaller drawdowns for the Duke Energy System
		Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
Water Quality	Reservoir Temperature and D.O. Stratification	Daily Average Drawdown Elevation	Little to no difference (<0.5 ft)	Little to no difference (<1 ft); Smaller drawdowns for the Duke Energy System	Little to no difference (<1 ft); Smaller drawdowns for the Duke Energy System
	Lower Savannah River D.O. and Salinity	Average JST Flow Release	Little to no difference; No difference in volume of daily minimum release	Little to no difference; No difference in volume of daily minimum release	Little to no difference; No difference in volume of daily minimum release
Recreation	Public Boat-Launching Ramps	Daily Average Drawdown Elevation	Increase of less than 2% of days in annual usability; Increase of 4,497 ramp days at USACE reservoirs	Decrease of less than 6% of days in annual usability; Decrease of 13,484 ramp days at USACE reservoirs; Measures included to retain boating access	Decrease of less than 7% of days in annual usability; Decrease of 15,701 ramp days at USACE reservoirs; Measures included to retain boating access
	Swimming		Little to no difference (<0.5 ft); Swimming areas become dry during droughts in USACE System	Little to no difference (<1 ft); Swimming areas become dry during droughts in USACE System	Little to no difference (<1 ft); Swimming areas become dry during droughts in USACE System

Resource		Modeling Parameter	Alternative Comparison with NAA / A1		
			A2	**A3**	**A4**
Biotic Communities - Reservoirs	Littoral Zone Fish and Mussel Habitat	Daily Average Reservoir Fluctuations	Little to no difference (< 0.01 foot)	Little to no difference (<0.01 foot)	Little to no difference (<0.01 foot)
	Pelagic Zone Fish Habitat	Mean September Drawdown Elevation	Little to no difference (infrequent larger drawdowns) (<2 foot) at Lake Jocassee; Studies indicate depth alone is not a limiting factor to pelagic fisheries	Smaller drawdowns at Duke Energy System; Little to no difference at USACE System	Smaller drawdowns at Duke Energy System; Little to no difference at USACE System
	Aquatic Plants, Wetlands and Wildlife	Daily Average Drawdown Elevation	Small difference (<0.5 foot)	Small difference (<1 foot); Smaller drawdowns at Lake Jocassee	Small difference (<1 foot); Smaller drawdowns at Lake Jocassee
Biotic Communities-Lower Savannah River	Fish and Mussel Habitat	Average JST Flow Release	Higher mean monthly flows for late winter and critical summer species; Lower mean monthly flows for spring spawning and fall juvenile fish outmigration	Higher mean monthly flows for late winter and critical summer species; Lower mean monthly flows for spring spawning and fall juvenile fish outmigration	Higher mean monthly flows for late winter and critical summer species; Lower mean monthly flows for spring spawning and fall juvenile fish outmigration
	Aquatic Plants, Wetlands and Wildlife	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
	Savannah National Wildlife Refuge	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)
	Protected Species	Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)

Resource		Modeling Parameter	Alternative Comparison with NAA / A1		
			A2	A3	A4
Environmental Justice and Protection of Children, Cultural Resources, Coastal Zone Consistency, Solid and Hazardous Waste Facilities, and Navigation	Human Health, Environmental Effects, and Economic Hardship, Historic Properties	Reservoirs - Daily Average Drawdown Elevation	Little to no difference (<0.5 foot)	Minor difference (<1 foot); Smaller drawdowns for the Duke Energy System; Larger drawdowns for the USACE System	Minor difference (<1 foot); Smaller drawdowns for the Duke Energy System; Larger drawdowns for the USACE System
		Lower Savannah River - Average JST Flow Release	Little to no difference (<2 cfs)	Minor increase (~8 cfs)	Little to no difference (<4 cfs)

The tables show that differences between the alternatives for the USACE reservoirs are generally small. The largest differences are in impacts to boating access at the USACE reservoirs as a result of changes in pool elevations during droughts. Those impacts vary from a positive $40,896 per year with A2 to a loss of $131,409 per year with A4. A1 would have the same effect on recreation as the NAA. A3 would result in somewhat less adverse impacts than A4 (loss of $113,670 per year). Duke Energy would mitigate those losses (A3 and A4) by providing funding and/or in-kind services to USACE and other public entities to improve public boating access at Hartwell and JST Reservoir facilities. The amount of funding would equal the expected adverse impacts (present worth of $2,938,000 with A3). A3 and A4 result in slightly higher reservoir elevations for Lakes Jocassee and Keowee compared to NAA, A1, and A2. As a result, environmental effects associated with A3 and A4 will likely be the same or a slight improvement for Lakes Jocassee and Keowee compared to the other alternatives. Changes in releases from the JST Project would be minimal because USACE would continue to follow its 2012 Drought Plan in the NAA and all alternatives. Therefore, environmental effects associated with all five alternatives will be very similar in the lower Savannah River. Only negligible differences were identified between the NAA and alternatives for other environmental resources.

From a socioeconomic perspective, there are no substantial differences were identified in the economy of the region between the alternatives.

No major differences were identified for the USACE system between alternatives in hydroelectric generation. A4 would result in slightly more generation for the Duke Energy system than the other alternatives. The NAA would require substantial replacement energy (approximately $913 million) and transmission system upgrade costs (approximately $232 million). Similarly, A1 would require ONS modification costs in excess of $800 million. Because of these large costs, neither of those two alternatives is preferred. A3 and A4 include much lower ONS modification capital costs, estimated at approximately $2 million.

Rationale for Recommended Alternative

The performance of the No Action Alternative and four action alternatives were evaluated over the 73-year Period Of Record. The alternatives would have resulted in similar USACE reservoir elevations and JST Project flow releases to the lower Savannah River. Differences between the alternatives occur infrequently, during droughts.

A3 and A4 include additional storage from the Bad Creek Project in the Duke Energy system. Those alternatives also include additional storage from the Richard B. Russell Project in the USACE system. This additional usable storage in the Duke Energy system reduces the risk of forced outages at the ONS during extreme droughts (thus preventing expensive energy replacement costs and transmission system upgrades); and provides additional storage that can be used to support other water users in the Upper Savannah River Basin.

NAA and A1 result in lower reservoir elevations for Lakes Jocassee and Keowee. During droughts, A2 maintains the highest Lake Keowee pool elevations. However, that is at the expense of Lake Jocassee, which experiences its lowest reservoir elevations with this alternative. During extreme droughts, A2 results in Lake Keowee elevations below 794.6 feet AMSL, which would negatively impact Duke's operation of the ONS. This would occur when the Lake Jocassee storage capacity is depleted, making it harder to maintain Lake Keowee reservoir elevations above 794.6 feet AMSL, increasing the risk of forced outages at the ONS.

A3 and A4 generally result in higher reservoir elevations for Lakes Jocassee and Keowee compared to the other alternatives. During less severe droughts, such as occurred at the end of 2006, A3 and A4 result in slightly lower elevations in Hartwell and JST Reservoirs (by approximately 0.7 feet and 0.5 feet, respectively) compared to the NAA and A1. During extreme droughts, there is little difference in Hartwell and JST Lake elevations between A3 and A4 and NAA/A1. The minor differences in reservoir elevations are not expected to result in additional adverse effects to the biological communities in the USACE Reservoirs or negatively impact social or socioeconomic resources in the Savannah River Basin.

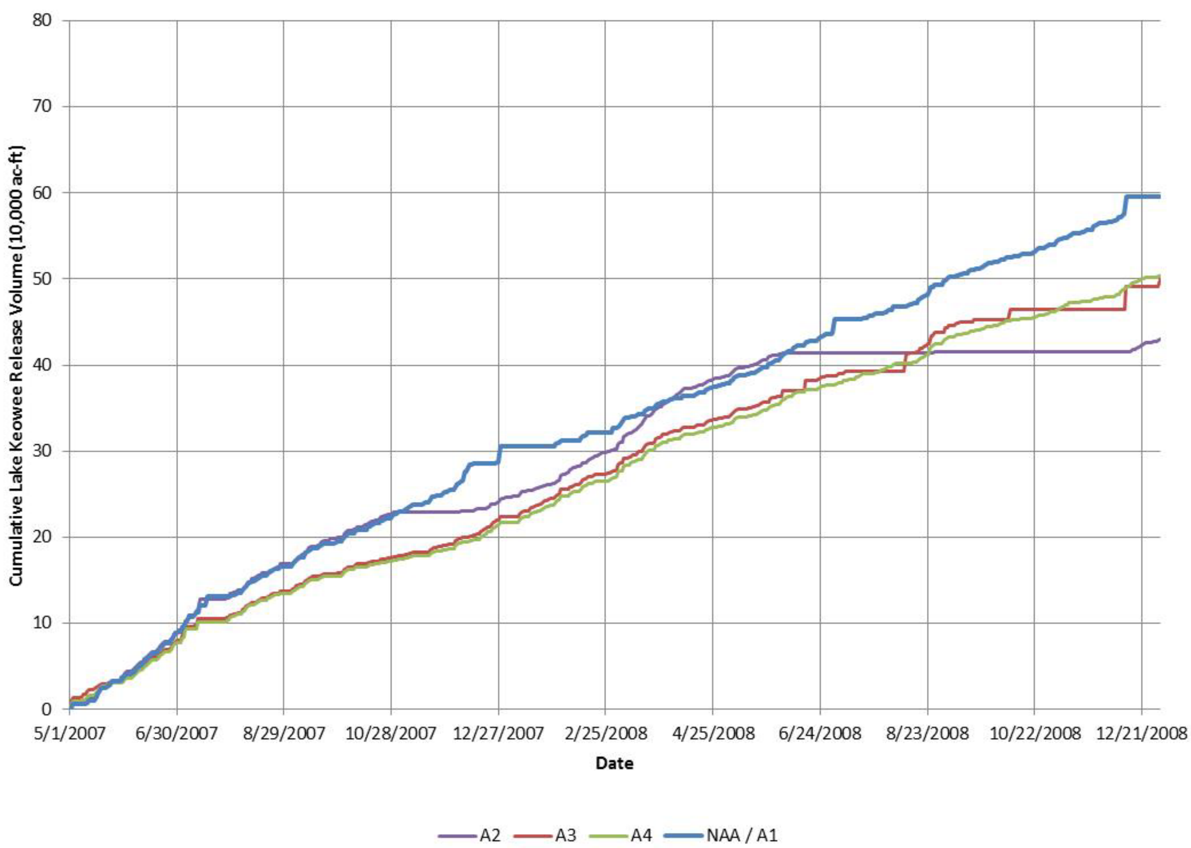
An analysis of flow releases from the JST Project for the April through December periods of drought (i.e., those years where the USACE's Drought Plan was triggered) reveals little difference in downstream flow releases between alternatives. Differences between A3/A4 and NAA/A1 are less than +/-5 percent on an annual basis. The larger negative differences (i.e., A3/A4 average flows are less than NAA/A1 flows) tend to occur during less severe droughts when average flows are well above 4,200 cfs. The larger positive differences tend to occur during recovery from extreme droughts. JST flow releases under A3 and A4 are more similar to NAA/A1 than are the A2 flow releases.

Figure 6.0-1 shows the releases from Lake Keowee to the USACE System toward the end of the drought of record (2007-2008). During this extreme drought, discharges from the Duke Energy system to the USACE system would be higher with the NAA and A1 than the other three alternatives. Flows with A3 and A4 would exceed those of A2 at the deepest part of the extreme drought (third quarter 2008), when releases would cease under A2 because of the limitations in Lake Keowee to enable the ONS to continue to operate.

During extreme droughts when the remaining usable storage in the Duke Energy system drops below 12 percent, Duke would cease to release water from Lake Keowee. However, an estimated 650 ac-ft of water per week would continue to flow into Hartwell Lake via leakage and seepage from the Keowee Development. This water volume would help keep Duke Energy's system storage within approximately 1 percent of the USACE's system storage in extreme droughts.

Net USACE hydroelectric generation results for A3 and A4 are similar to the other alternatives.

Figure 6.0-1 Cumulative Lake Keowee Volume Released to the USACE System (With Adaptive Management Winter Flows) (Future Water Withdrawals with Historic Hydrology)



NAA requires ONS energy replacement costs of approximately $913 million and potential transmission system upgrade costs of up to $232 million. A1 requires ONS station modification costs of at least $800 million. The high costs of A1 and A2 are not justified by the benefits to USACE reservoirs or downstream areas. Adverse impacts to users of the USACE reservoirs could be mitigated by improving access at public ramps on those reservoirs.

The $2 million modification to the ONS in A3 and A4 provides additional usable storage capacity in the Duke Energy system that helps maintain ONS operations (thus preventing expensive energy replacement costs and transmission system upgrades); provides additional storage that can be used to support other water users in the Upper Savannah River Basin; and provides downstream flow releases to the USACE system during the deepest parts of drought periods.

Under A3 and A4, adaptive management flow releases to address downstream water quality concerns during extreme droughts may result in slightly lower Hartwell and JST Lake elevations (by less than 0.4 feet in each reservoir). Duke Energy would offset the effects of these lower lake elevations by providing funding for Interim #3 of the USACE's Savannah River Basin Comprehensive Study and public boating access improvements at Hartwell and JST Lakes. These funding measures are directly related to enhancing drought tolerance in the Upper Savannah River Basin and improving recreation opportunities on the USACE Reservoirs that would be affected by operation of the Duke Energy system during droughts.

In summary, A3 and A4 are better from a Duke Energy system operations perspective than NAA, A1 or A2. These two alternatives result in minor impacts to the USACE reservoir system during extreme droughts. These impacts are offset by drought tolerance and funding measures. A4 does not include the Low Inflow Protocol (drought tolerance measure) similar to what it included in its 2013 Relicensing Agreement for the Keowee-Toxaway Project. Duke Energy prefers A3 and that alternative has been accepted by Duke Energy's stakeholders through their concurrence in the 2013 Relicensing Agreement.

6.0 RECOMMENDED ALTERNATIVE

A3 is the Recommended Alternative because it best balances the competing interests of reservoir levels, risks to operation of the ONS, downstream flow releases, hydroelectric generation, social and biological communities, recreation, and economic costs. Under A3, Duke Energy would modify the ONS to allow operations to continue at Lake Keowee elevations down to 790 feet AMSL. Duke Energy would bear the estimated $2 million cost of those modifications to provide additional operating margin and risk mitigation. The modification costs are significantly lower than the costs associated with forced outages of the ONS (both replacement power and transmission system upgrades) or ONS engineering modifications that would allow operations at Lake Keowee reservoir elevations down to 778 feet AMSL (as required by the 1968 Agreement). Duke would implement these station modifications by November 30, 2019.

Duke Energy expects to modify operations of the Keowee-Toxaway Project as a result of its ongoing FERC relicensing of that facility. A3 conforms to the Relicensing Agreement that Duke and its stakeholders signed on November 20, 2013. As such, the effects of A3 have already been reviewed by Duke's stakeholders and found to be acceptable.

In general, A3 would modify the 1968 Agreement as follows:

- Incorporate additional storage capacity in Duke Energy's Bad Creek Reservoir and USACE's RBR Reservoir into the calculations determining the remaining usable storage and weekly water release requirement from Lake Keowee. As a result, A3 equalizes the percentage of combined remaining usable storage capacity at USACE's Hartwell, RBR, and JST Reservoirs with the percentage of combined remaining usable storage capacity at Duke Energy's Bad Creek Reservoir and Lakes Jocassee and Keowee.
- Revise the Lake Keowee minimum elevation for calculation of usable storage to elevation 790 feet AMSL (which allows for a 10-foot drawdown of Lake Keowee).
- Lower the Lake Jocassee minimum reservoir elevation six feet (from 1086 feet AMSL to 1080 feet AMSL) and eliminate the allowance for pumping volume in the weekly water release calculation.
- Incorporate the USACE July 2012 Drought Plan operating protocols.

- Incorporate Duke Energy's Low Inflow Protocol (LIP) which provides rules for how they will operate their reservoirs during droughts, including minimum lake elevations and water use conservation for existing and future water intake owners located on Keowee-Toxaway Project Reservoirs.

A3 also includes the following provisions to enhance drought tolerance in the Upper Savannah River Basin:

- Duke Energy will require owners of Large Water Intakes on the Duke Energy Projects to comply with its Low Inflow Protocol.
- USACE will require any owner of a Large Water Intake (i.e., water intake with a maximum capacity greater than or equal to one million gallons per day) who is allocated water from the USACE Projects after the effective date of the new Operating Agreement to implement coordinated water conservation measures when the USACE Drought Plan is in effect (similar to the water conservation measures required by the Low Inflow Protocol for Large Water Intake owners on the Duke Energy Projects).
- USACE and Duke Energy will encourage all water users withdrawing water from their respective reservoirs to conserve water in a coordinated manner when the USACE Drought Plan is in effect (similar to the water conservation measures required by the LIP on Duke Energy Projects).
- USACE and Duke Energy will require (whenever feasible) that all Large Water Intakes used for municipal, industrial and power generation purposes that are constructed, expanded or rebuilt on their projects after the effective date of the new Operating Agreement be capable of operating at their permitted capacities at reservoir elevations as low as the applicable hydroelectric station can operate.
- Duke Energy would provide $438,000 in funding to support the next interim of the USACE Savannah River Basin Comprehensive Study (to evaluate reallocating existing storage or measures that could lead to better water management).
- Duke Energy would provide funding and/or in-kind services to USACE and other public entities to improve public boating access at Hartwell and JST Reservoir facilities to fully

mitigate for adverse impacts to recreational access to those reservoirs. Those impacts are presently estimated to be $2,938,000 (FY14 price levels).

To avoid adverse impacts to dissolved oxygen levels in Savannah Harbor, A3 contains the following provision: USACE and Duke Energy will discharge 200 cubic feet per second of water above that specified in the Drought Plan from their dams for 11 days when the USACE reservoirs are in drought status during the summer months.

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APPENDICES